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FLOOD PLAIN INFORMATION RED CLAY CREEK, NEW CASTLE COUNTY, DELA--ETC(U)
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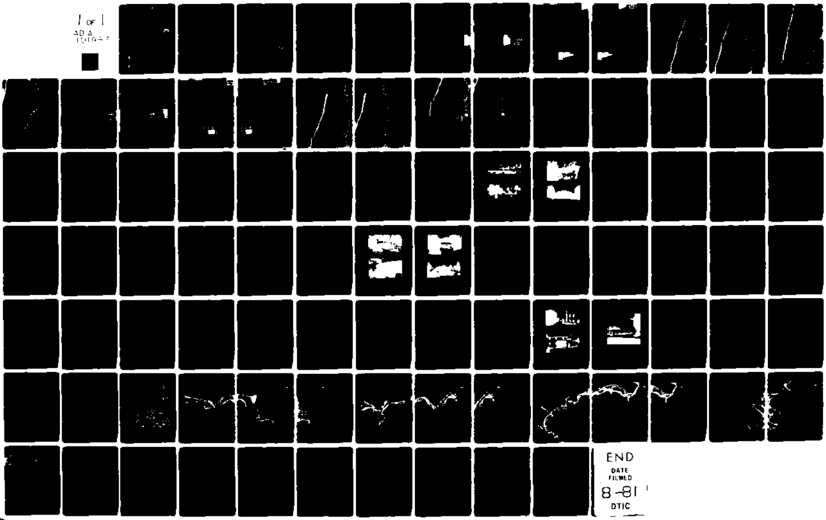

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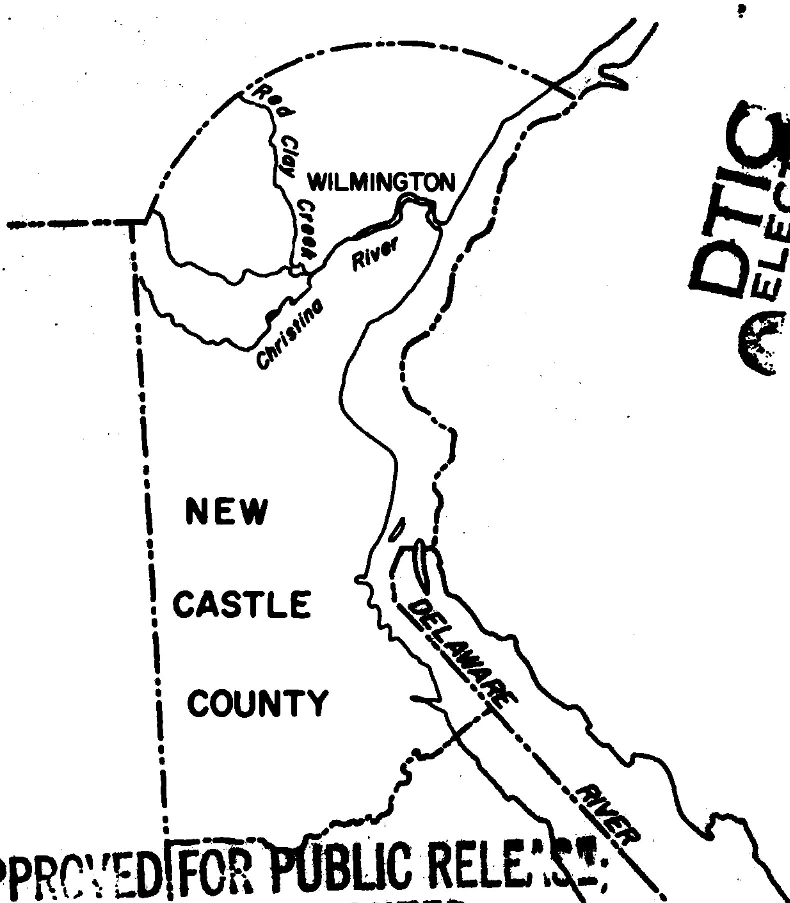
FLOOD PLAIN INFORMATION

RED CLAY CREEK
NEW CASTLE COUNTY
DELAWARE



PREPARED FOR
NEW CASTLE COUNTY DEPARTMENT OF PLANNING
BY
CORPS OF ENGINEERS, U. S. ARMY
PHILADELPHIA DISTRICT
FEBRUARY 1971

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REPT. NO: DAEN/NAP-82040/FPI38-71/02

TO THE REQUESTOR:

This Flood Plain Information (FPI) Report was prepared by the Philadelphia District office of the U.S. Army Corps of Engineers, under the continuing authority of the 1960 Flood Control Act, as amended. The report contains valuable background information, discussion of flood characteristics and historical flood data for the study area. The report also presents through tables, profiles, maps and text, the results of engineering studies to determine the possible magnitude and extent of future floods, because knowledge of flood potential and flood hazards is important in land use planning and for management decisions concerning floodplain utilization. These projections of possible flood events and their frequency of occurrence were based on conditions in the study area at the time the report was prepared.

Since the publication of this FPI Report, other engineering studies or reports may have been published for the area. Among these are Flood Insurance Studies prepared by the Federal Insurance Administration of the Federal Emergency Management Agency, Flood Insurance Studies generally provide different types of flood hazard data (including information pertinent to setting flood insurance rates) and different types of floodplain mapping for regulatory purposes and in some cases provide updated technical data based on recent flood events or changes in the study area that may have occurred since the publication of this report.

It is strongly suggested that, where available, Flood Insurance Studies and other sources of flood hazard data be sought out for the additional, and, in some cases, updated flood plain information which they might provide. Should you have any questions concerning the preparation of, or data contained in this FPI Report, please contact:

U.S. Army Corps of Engineers
Philadelphia District
Custom House, 2nd and Chestnut Streets
Philadelphia, PA 19106

ATTN: Flood Plain Mgt. Services Branch, NAPEN-M

Telephone number: (215) 597-4807

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER DAEN/NAP-82040/FPI38-71/02	2. GOVT ACCESSION NO. AD-A101 987	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Flood plain information, Red Clay Creek, New Castle County, Delaware,		5. TYPE OF REPORT & PERIOD COVERED Flood plain information
		6. PERFORMING ORG. REPORT NUMBER DAEN/NAP-82040/FPI38-71/02
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Red Clay Creek, Dela. New Castle County, Dela. New Castle County Dept. of Planning Floods Flood forecasting Flood plains		

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report covered the flood situation along Red Clay Creek from its confluence with White Clay Creek South of Stanton, Dela. upstream to the Pennsylvania-Delaware state line near Yorklyn, Delaware. It included information on rainfall, runoff, historical flood heights and other technical data bearing upon the occurrence and size of floods within the study area. Maps, profiles and cross sections which show the extent of floods which may occur in the future were also described.

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Under authority of Section 206 of the 1960 Flood Control Act as amended the flood plain information was prepared by the U.S. Army Corps of Engineers Philadelphia District at the request of the New Castle County Department of Planning. The information should be considered for its historical nature. Since the publication of this FPI report other Flood Insurance studies have been undertaken and should also be consulted for more current information.

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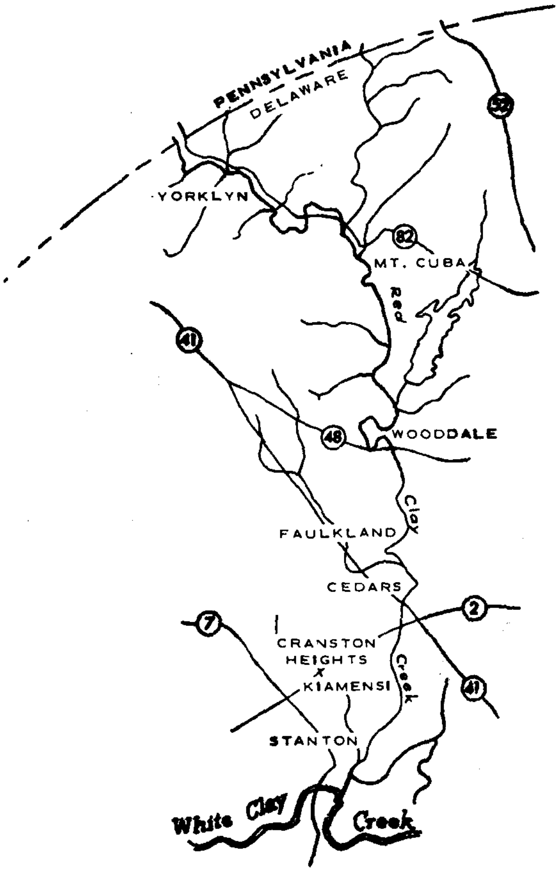
NOTICE

FLOODS IN MT. CUBA-YORKLYN VICINITY, DELAWARE

— — How to Avoid Damage



FEBRUARY 1971

FLOODS IN MT. CUBA - YORKLYN VICINITY, DELAWARE

The greatest flood in the Mt. Cuba - Yorklyn vicinity occurred on July 24, 1938. The swollen Red Clay Creek inundated the Marshall Brothers, Inc., Plant, Yorklyn, damaging seven million pounds of baled rags beyond salvage. Three covered bridges were battered and one was washed away.

Seldom does Red Clay Creek overflow its banks and fill its flood plain to heights close to those reached on July 24, 1938. Minor flooding, however, occurs about twice a year. Increased residential and commercial developments within the flood plain could seriously be affected by large floods injuring the economy and general welfare of the community.

Recurring damages are unnecessary. Information to guide safe community developments and methods for reducing future flood damages are available. The New Castle County Department of Planning feels that citizens should be aware that large floods may be expected and that damage can be greatly reduced only if proper precautionary measures are taken.

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FUTURE FLOODS

Floods higher than those of the past can occur. Studies of this area indicate that future floods could be significantly greater than past floods.

below the National Vulcanized Fibre Plant.

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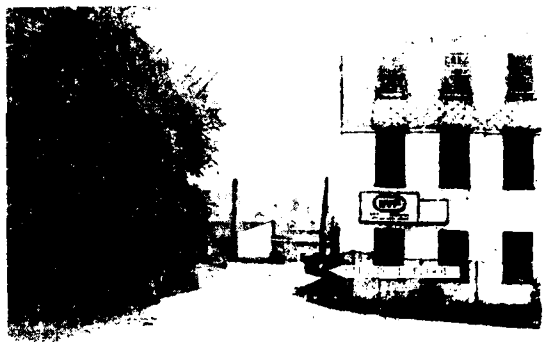

Photograph 1 - Possible future flood heights at the National Vulcanized Fibre Plant.

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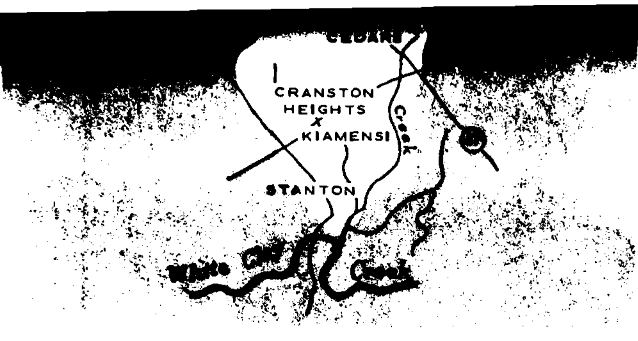

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Photograph 1 shows the Intermediate Regional Flood and the Standard Project Flood heights at the National Vulcanized Fibre Plant, Yorklyn. Photograph 2 shows a small dam upstream from Sharpless Road located one mile below the National Vulcanized Fibre Plant.

POSSIBLE SOLUTIONS

There are means of protecting buildings against flood waters, and some of them can be handled by the individuals involved. These include the permanent or temporary closure of lower openings, the use of flap gates on sewer lines, the waterproofing of walls and floors, and the provision of removable bulkheads for the temporary protection of exposed entrances. There are also many ways in which the community at large can eliminate or lessen the flood damage potential. Regulating development in the flood

Photograph 2 - Typical dam across Red Clay Creek at Mile 10.49.

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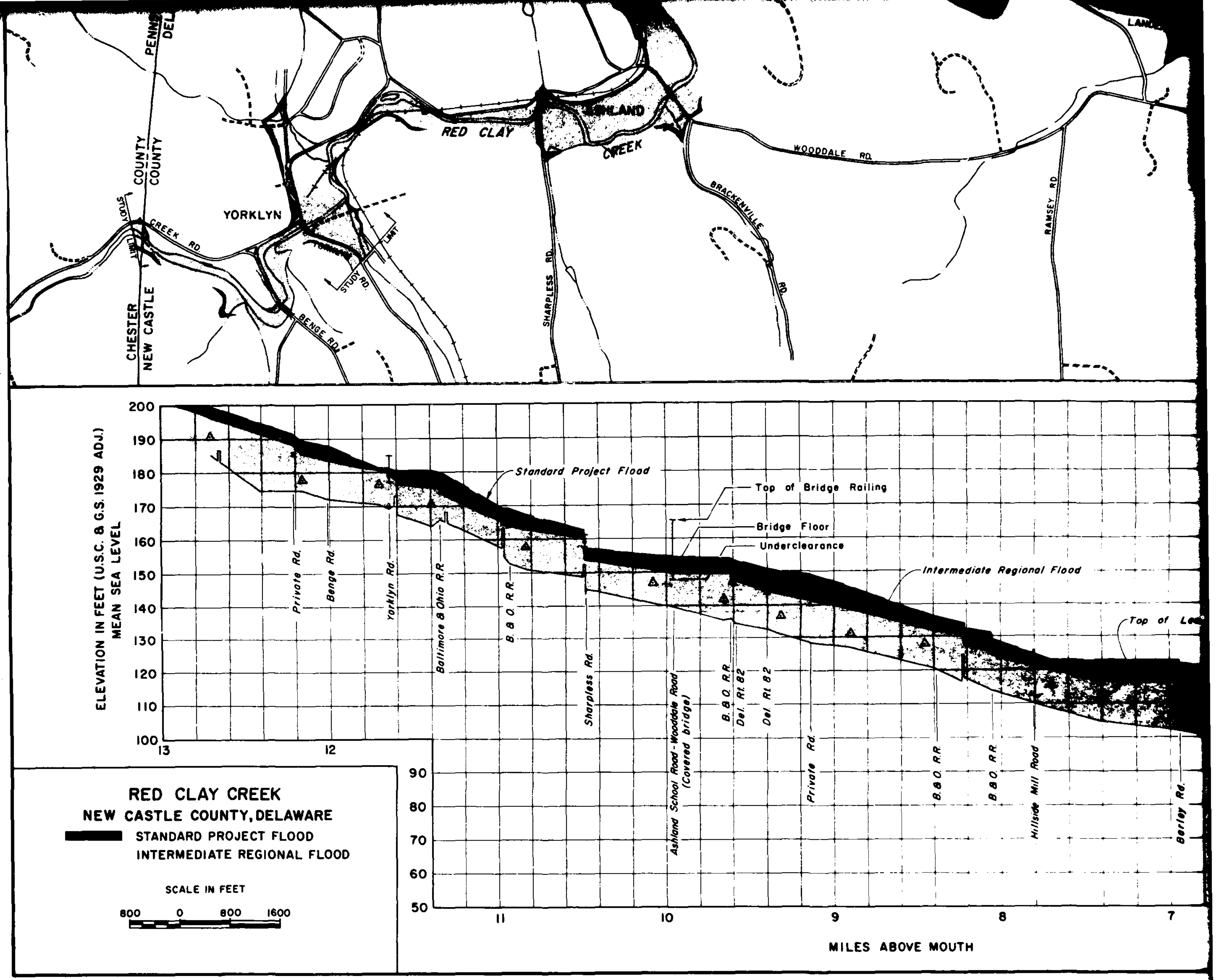
Information on protecting your own property and for developing a sound flood plain management program for your community can be obtained through the County Department of Planning.

* * *

This folder has been prepared for New Castle County by the Corps of Engineers from data in the report "Flood Plain Information, Red Clay Creek, New Castle County, Delaware". Copies of that report and this folder are available from the New Castle County Department of Planning, County Engineering Building, Robert Kirkwood Highway, Box 165, Wilmington, Delaware 19899, and the Delaware State Highway Department, P. O. Box 778, Dover, Delaware 19901.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SHARPLESS RD
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MILES ABOVE MOUTH
Private Rd.
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B. & O. R.R.
Sharpless Rd.
Ashland School Road - Wooddale Road
(Covered bridge)
B. & O. R.R.
Del. Rt. 82
Del. Rt. 82
Private Rd.
B. & O. R.R.
B. & O. R.R.
Hillside Mill Road
Berley Rd.
Standard Project Flood
Top of Bridge Railing
Bridge Floor
Underclearance
Intermediate Regional Flood
RED CLAY CREEK
NEW CASTLE COUNTY, DELAWARE
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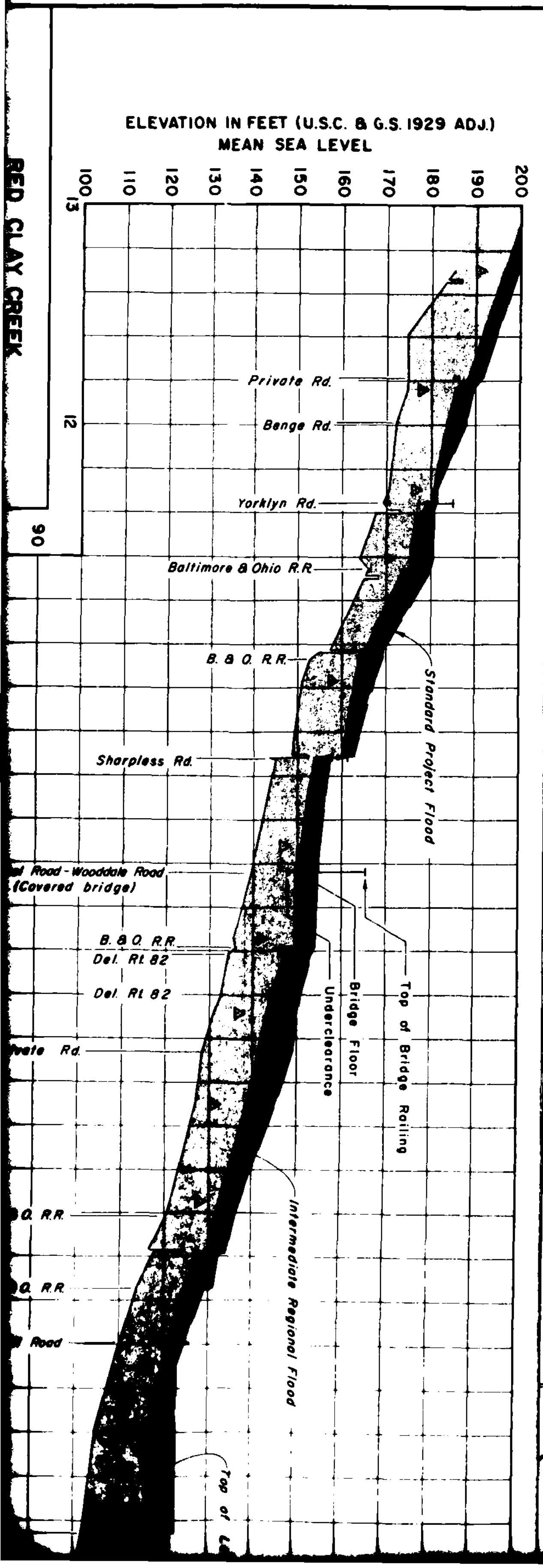

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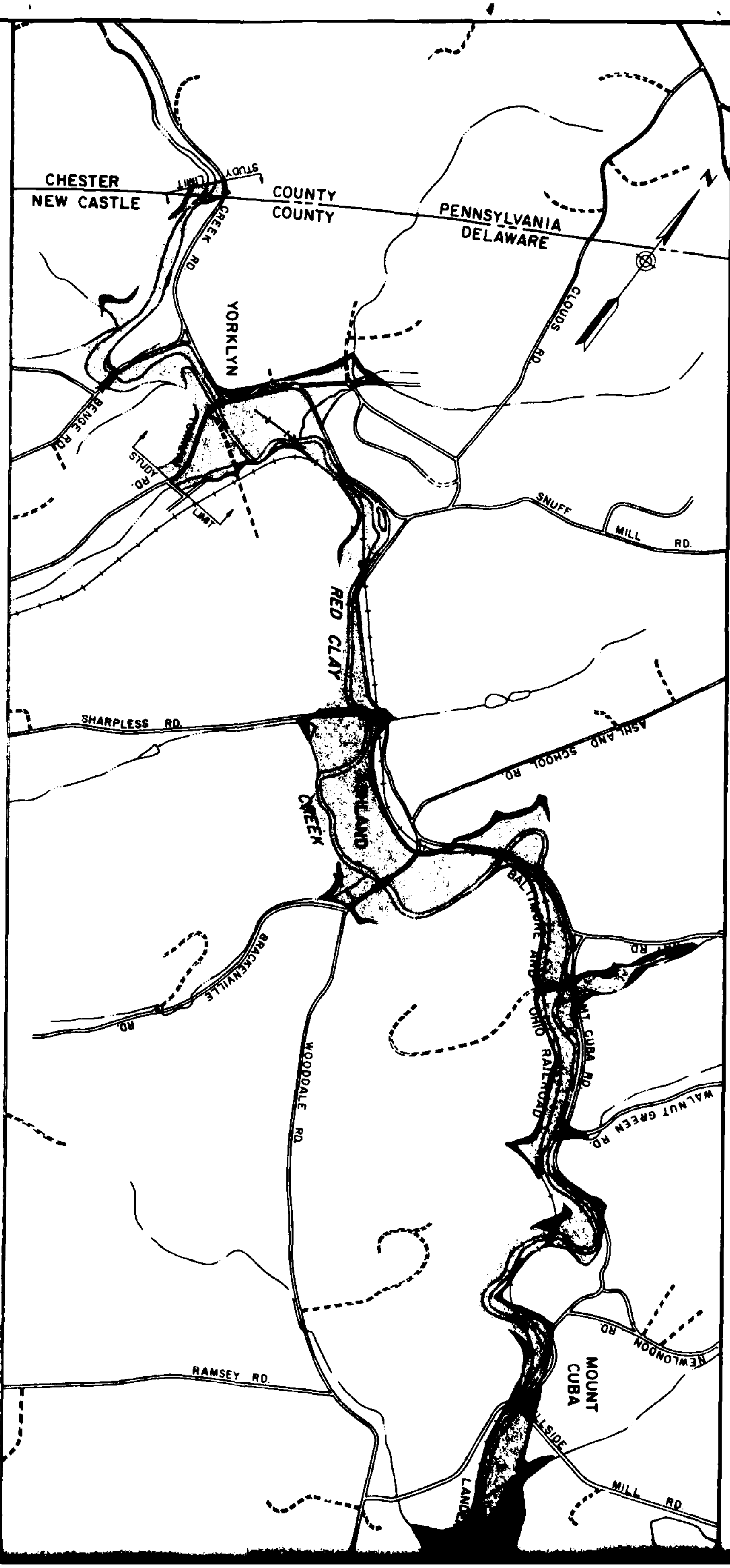
Intermediate Regional Flood



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SHARPLESS RD.
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BALTIMORE AND OHIO RAILROAD
BRACKENVILLE RD.
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WALNUT GREEN RD.
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MOUNT CUBA
RAMSEY RD.
MILL RD.


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RAMSEY RD.
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ROLLING MILL RD.
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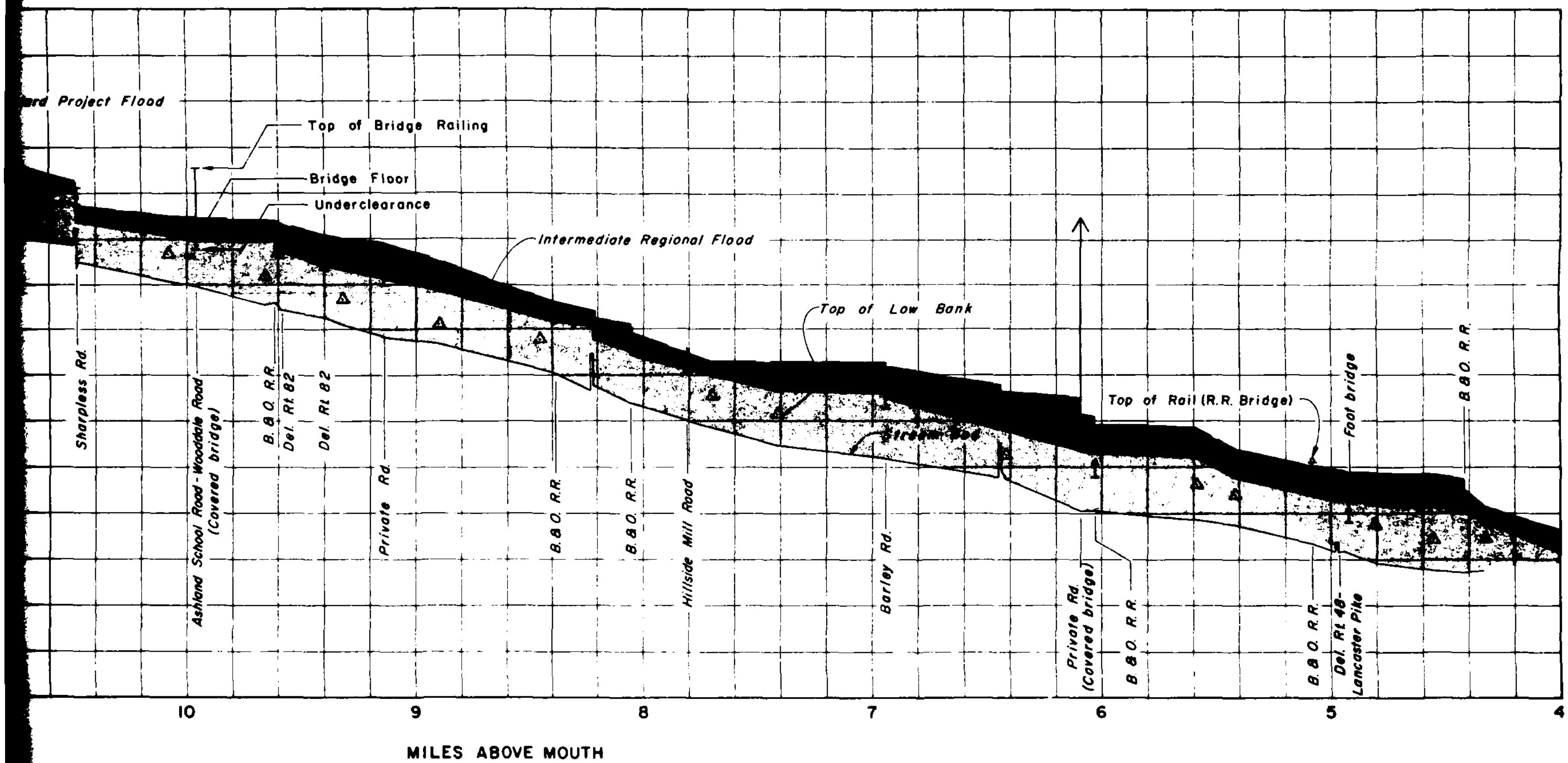
HERCULES RD.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Top of Low Bank
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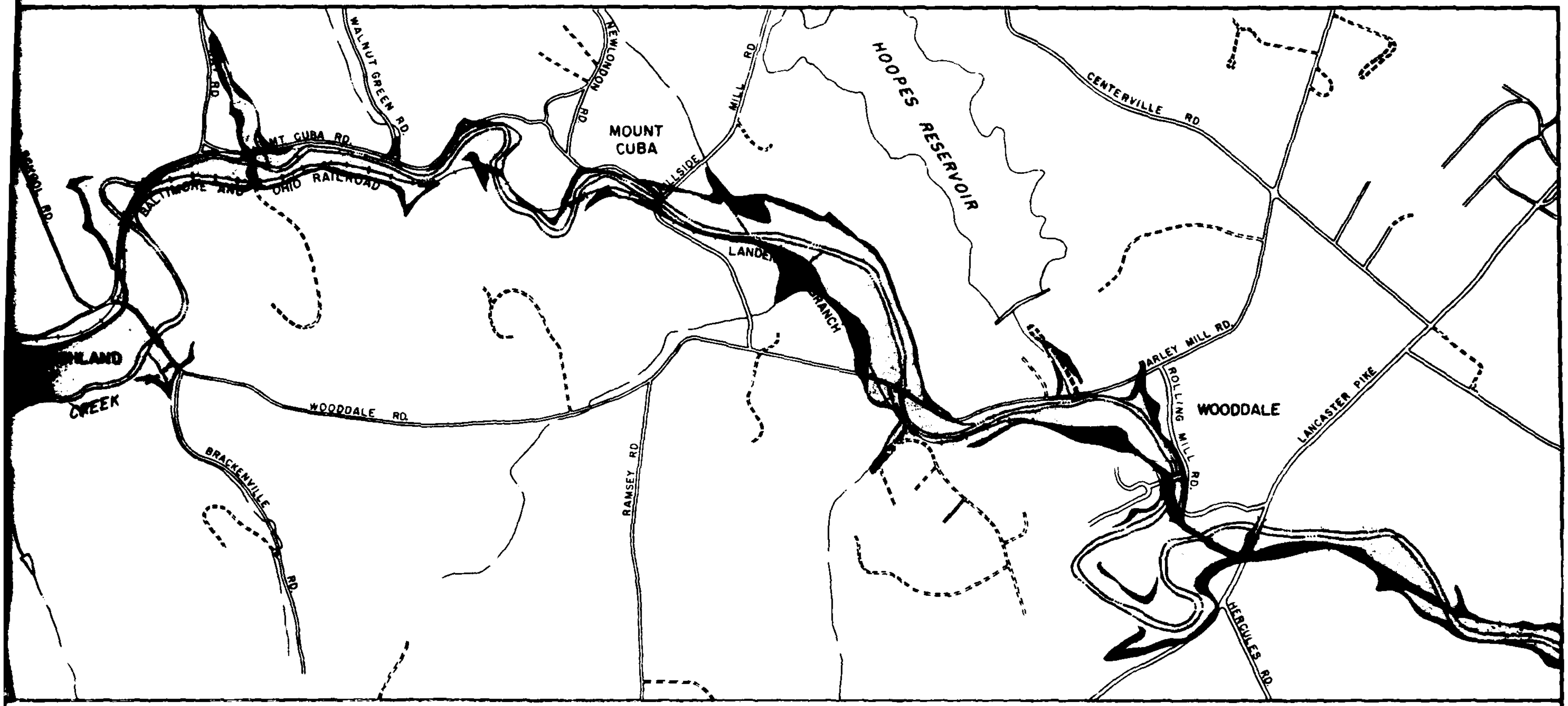

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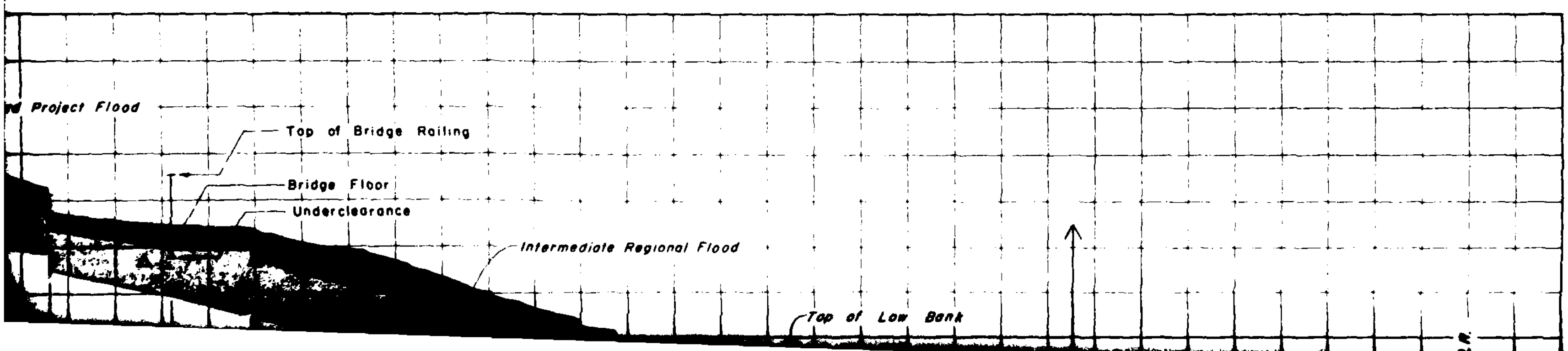

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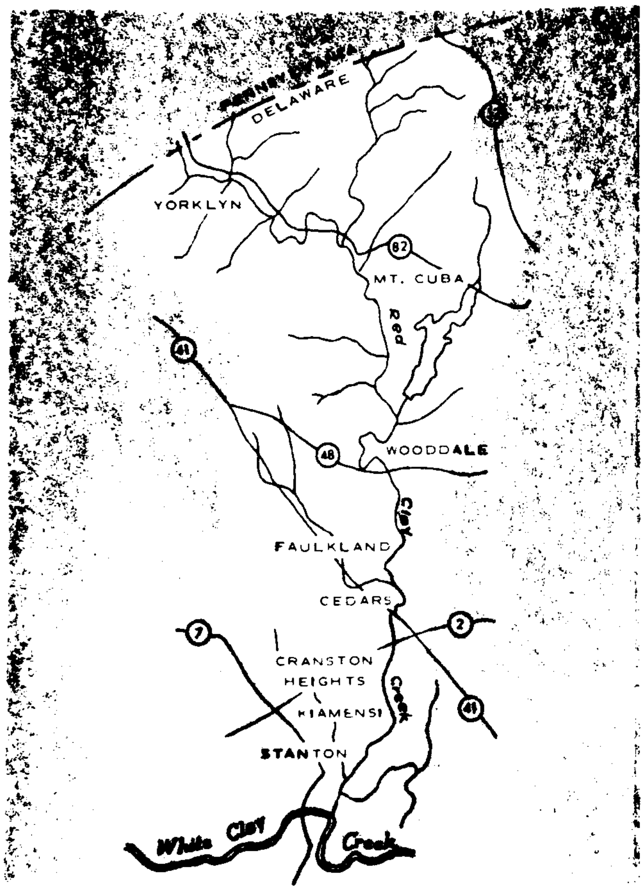
FLOODS IN -
FAULKLAND-STANTON VICINITY, DELAWARE

== How To Avoid Damage



FEBRUARY 1971

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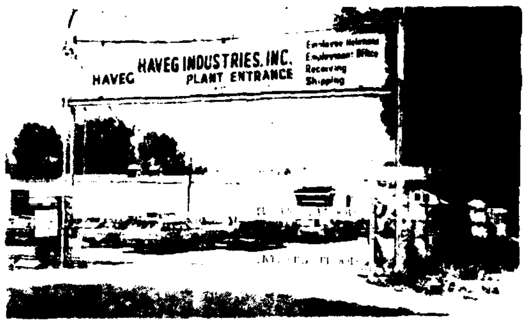

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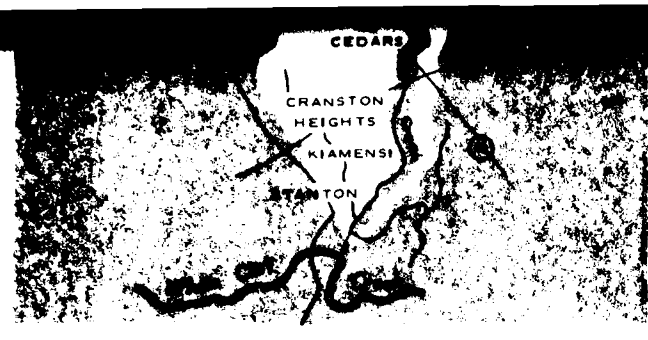

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Photograph 2 - Possible future flood heights at historic Greenbank Mill in Cedars.

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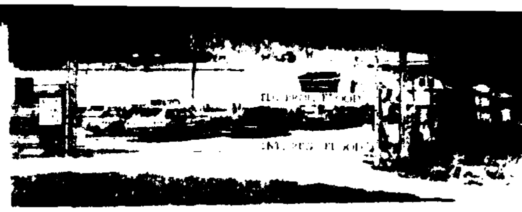

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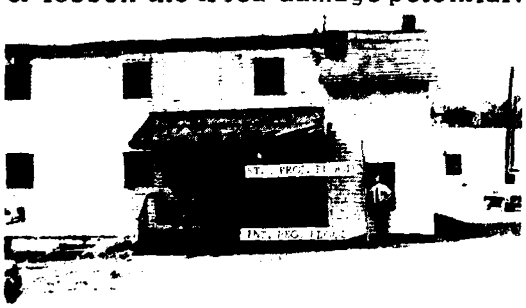

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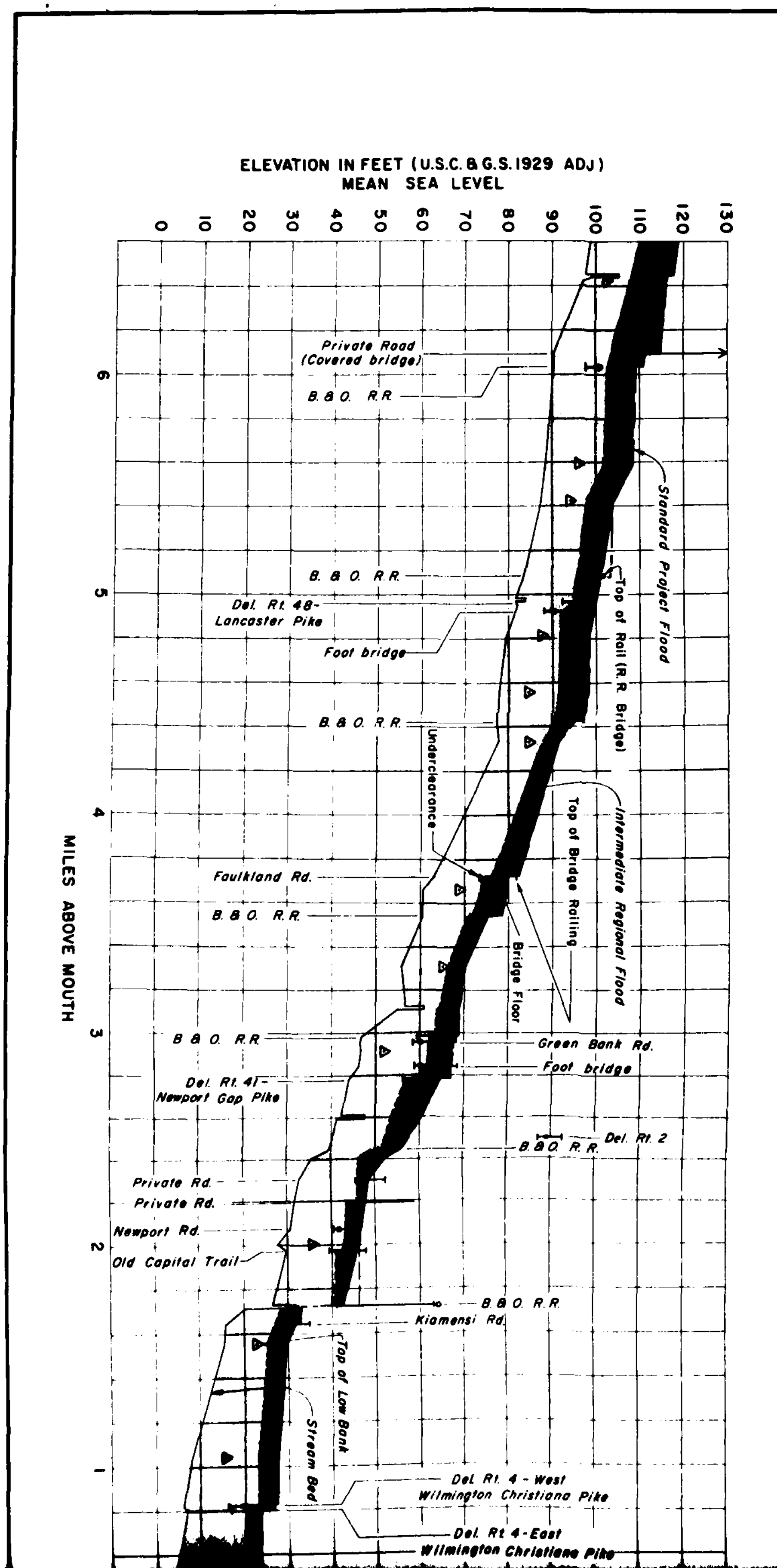
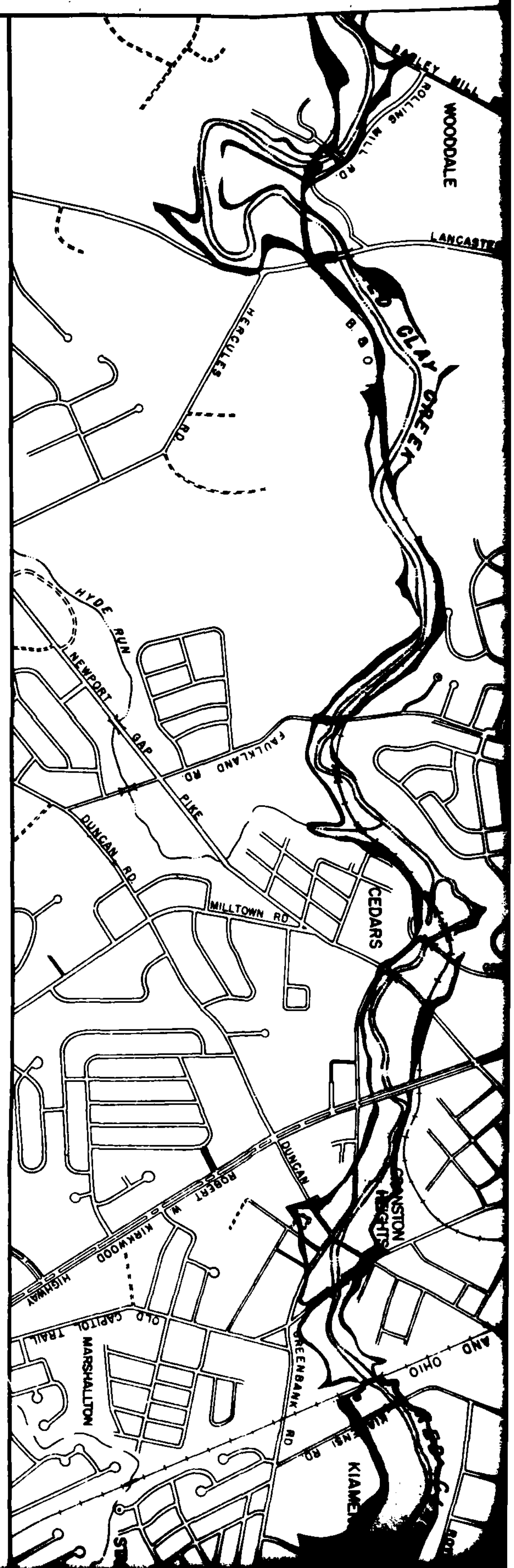
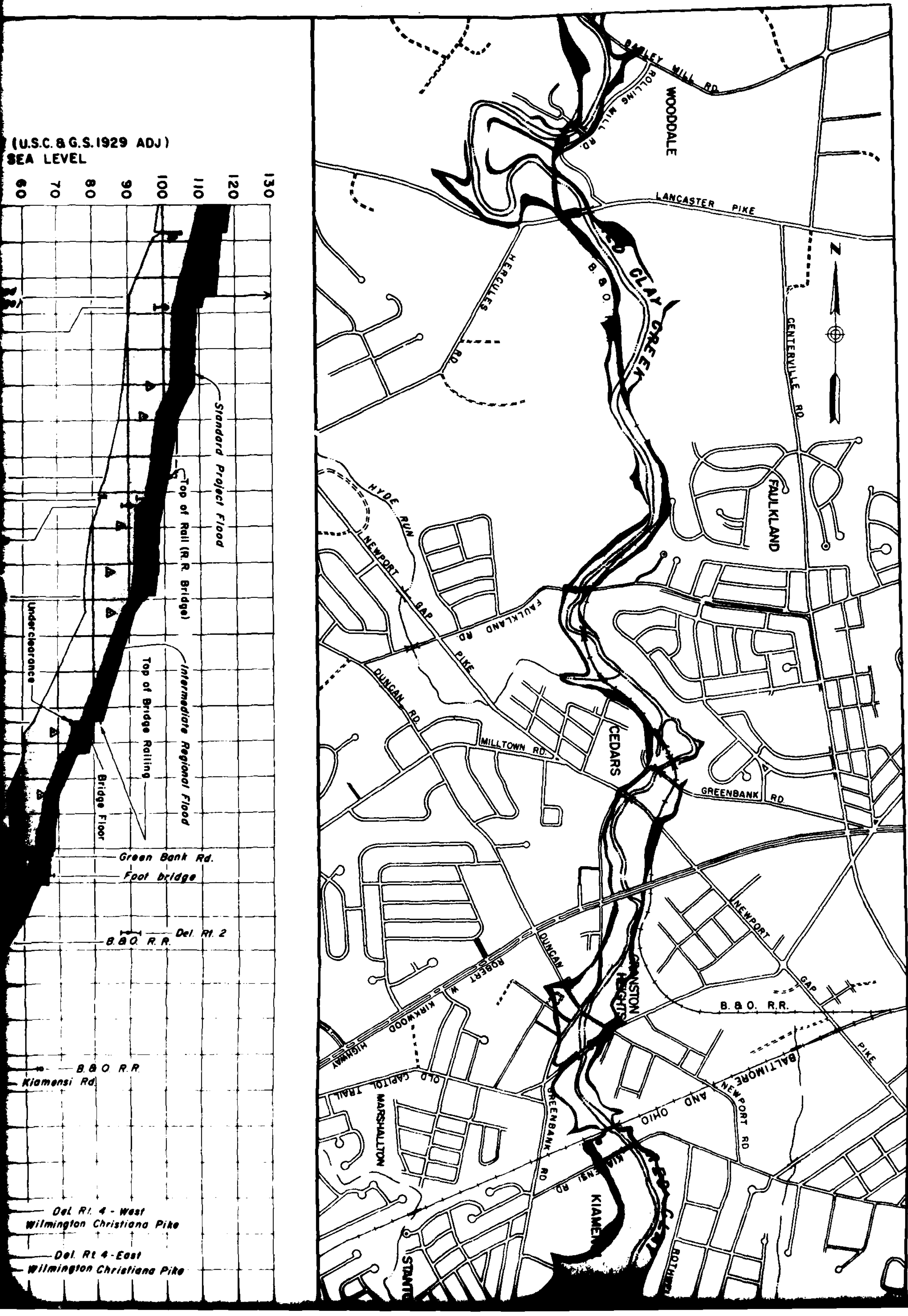
Information on protecting your own property and for developing a sound flood plain management program for your community can be obtained through the County Department of Planning.

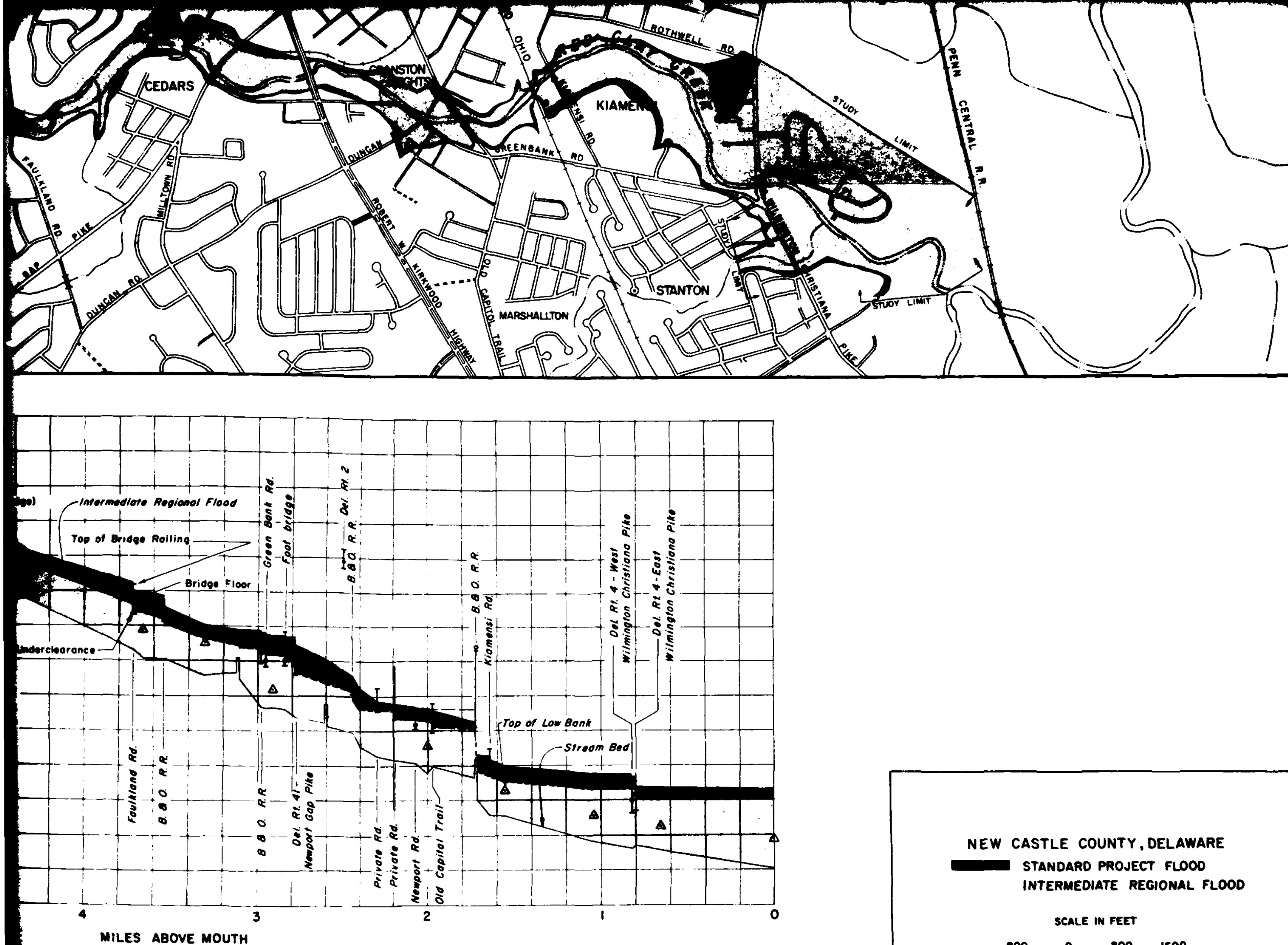
* * *

This folder has been prepared for New Castle County by the Corps of Engineers from data in the report "Flood Plain Information, Red Clay Creek, New Castle County, Delaware". Copies of that report and this folder are available from the New Castle County Department of Planning, County Engineering Building, Robert Kirkwood Highway, Box 165, Wilmington, Delaware 19899, and the Delaware State Highway Department, P. O. Box 778, Dover, Delaware 19901.


ELEVATION IN FEET (U.S.C.&G.S.1929 ADJ)
MEAN SEA LEVEL
0
10
20
30
40
50
60
70
80
90
100
110
120
130
MILES ABOVE MOUTH
1
2
3
4
5
6
Private Road
(Covered bridge)
B. & O. R.R.
Standard Project Flood
B. & O. R.R.
Top of Rail (R.R. Bridge)
Del. Rt. 48-
Lancaster Pike
Foot bridge
B. & O. R.R.
Underclearance
Intermediate Regional Flood
Top of Bridge Railing
Faulkland Rd.
B. & O. R.R.
Bridge Floor
B. & O. R.R.
Green Bank Rd.
Foot bridge
Del. Rt. 41-
Newport Gap Pike
Del. Rt. 2
B. & O. R.R.
Private Rd.
Private Rd.
Newport Rd.
Old Capital Trail
B. & O. R.R.
Kiamensi Rd.
Top of Low Bank
Stream Bed
Del. Rt. 4 - West
Wilmington Christiana Pike
Del. Rt 4-East
Wilmington Christiana Pike


BARLEY MILL RD.
ROLLING MILL RD.
WOODDALE
LANCASTER
RED CLAY CREEK
B. & O.
HERCULES RD.
HYDE RUN
NEWPORT GAP PIKE
FAULKLAND RD.
DUNCAN RD.
MILLTOWN RD.
CEDARS
ROBERT KIRKWOOD HIGHWAY
DUNCAN
CRANSTON HEIGHTS
OLD CAPITOL TRAIL
MARSHALLTON
GREENBANK RD.
KIAMENSI RD.
OHIO
AND


(U.S.C. & G.S. 1929 ADJ)
SEA LEVEL
60
70
80
90
100
110
120
130
Standard Project Flood
Top of Rail (R.R. Bridge)
Intermediate Regional Flood
Top of Bridge Railing
Underclearance
Bridge Floor
Green Bank Rd.
Foot bridge
Del. Rt. 2
B.&O. R.R.
B.&O R.R.
Kiamensi Rd.
Del. Rt. 4 - West
Wilmington Christiana Pike
Del. Rt. 4 - East
Wilmington Christiana Pike
BARLEY MILL RD.
ROLLING MILL RD.
WOODDALE
LANCASTER PIKE
RED CLAY CREEK
B. & O.
HERCULES RD.
CENTERVILLE RD.
N
FAULKLAND
HYDE RUN
NEWPORT GAP PIKE
FAULKLAND RD
DUNCAN RD.
MILLTOWN RD.
CEDARS
GREENBANK RD
NEWPORT
GAP
PIKE
B. & O. R.R.
ROBERT W. KIRKWOOD HIGHWAY
DUNCAN
BALTIMORE AND OHIO
NEWPORT RD
OLD CAPITOL TRAIL
MARSHALLTON
GREENBANK RD
KIAMENSI RD
KIAMEN
RED CLAY



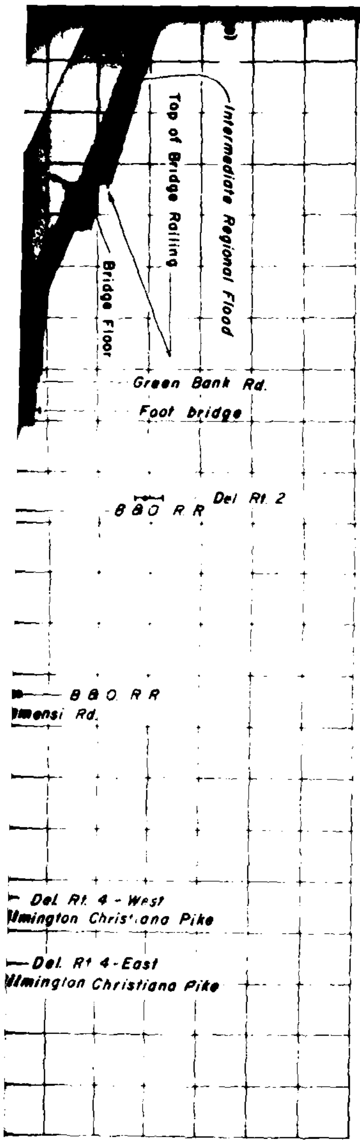
NEW CASTLE COUNTY, DELAWARE

STANDARD PROJECT FLOOD

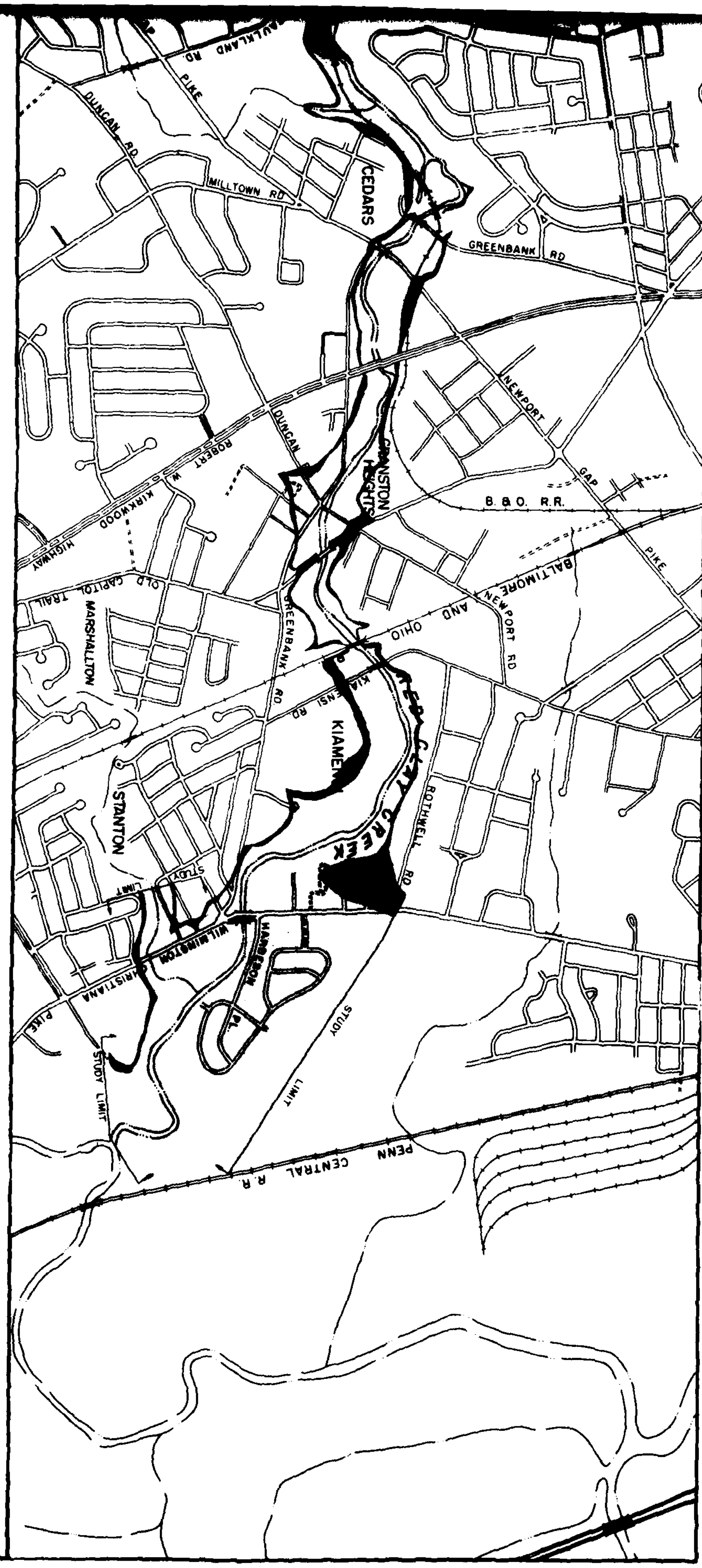
INTERMEDIATE REGIONAL FLOOD

SCALE IN FEET

800 0 800 1600



Intermediate Regional Flood
Top of Bridge Railing
Bridge Floor
Green Bank Rd.
Foot bridge
B&O RR
Del Rt. 2
B&O RR
mensi Rd.
Del. Rt. 4 - West
lmington Christ'ana Pike
Del. Rt 4-East
lmington Christiana Pike



KIRKLAND RD.
PIKE
DUNCAN RD.
MILLTOWN RD.
CEDARS
GREENBANK RD.
NEWPORT
GAP
PIKE
B.&O. R.R.
CRANSTON HEIGHTS
DUNCAN
ROBERT W. KIRKWOOD HIGHWAY
OLD CAPITOL TRAIL
MARSHALLTON
GREENBANK RD.
BALTIMORE AND OHIO
NEWPORT RD.
KIAMENSI RD.
KIAMEN
CREEK
ROTHWELL RD.
STANTON
STUDY LIMIT
WILMINGTON CHRISTIANA PIKE
HARRISON
PL.
STUDY LIMIT
STUDY LIMIT
PENN CENTRAL R.R.

FLOOD PLAIN INFORMATION
RED CLAY CREEK
NEW CASTLE COUNTY
DELAWARE

PREPARED FOR
NEW CASTLE COUNTY DEPARTMENT OF PLANNING
BY
CORPS OF ENGINEERS, U. S. ARMY
PHILADELPHIA DISTRICT
FEBRUARY 1971

REPT. NO: DAEN\NAP - 82040 | FPI38 - 71 | 02

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INTRODUCTION

This report covers the flood situation along Red Clay Creek from its confluence with White Clay Creek south of Stanton, Delaware, upstream to the Pennsylvania - Delaware State Line near Yorklyn, Delaware. It was prepared at the request of the New Castle County Department of Planning to aid in the solution of local flood problems and in the best utilization of flood-prone lands. The report is based upon information on rainfall, runoff, historical flood heights and other technical data bearing upon the occurrence and size of floods within the study area.

Two significant phases of the local flood problem are covered in this report. The first covers the largest known floods that have occurred within the study area. The second phase deals with possible future floods; namely, the Intermediate Regional Flood and the Standard Project Flood. A description of these possible future floods and the method of their derivation is given on pages 28 through 31 of this report.

In analyzing problems concerned with the control of development in the flood plains of that portion of Red Clay Creek located within the study area and in reaching decisions on the size of floods to consider for this purpose, appropriate consideration should be given to the possible recurrence of floods equal to those of the past and to the Intermediate Regional and Standard Project Floods.

The report contains maps, profiles and cross sections which show the extent of floods which might occur in the future. High water marks from past floods are also shown on the profiles. These

should prove helpful in planning the best use of the flood plains. From the profiles, the depth of probable flooding by the occurrence of either the Intermediate Regional or Standard Project Floods at any location may be obtained. With this information, floor levels for structures may be planned high enough to avoid flood damage or, if located at lower elevations, with recognition of the chance of flooding and the hazards involved.

The report does not include plans for the solution of flood problems. Rather, it is intended to provide the basis for further study and planning on the part of local authorities in arriving at solutions to minimize vulnerability to flood damage. This might involve county or local planning programs to guide developments by controlling the type of use made of the flood plains through zoning and subdivision regulations, the construction of flood protection works, or a combination of the two approaches.

The Philadelphia District of the U. S. Army Corps of Engineers will, upon request, provide technical assistance to Federal, state and local agencies in the interpretation and use of the information contained herein and will provide other available flood data related thereto.

SUMMARY OF FLOOD SITUATION

The East and West Branches of Red Clay Creek have their headwaters in Chester County, Pennsylvania, above the town of Kennett Square. They unite to form the main stem about 0.75 mile north of the Pennsylvania - Delaware State Line. The creek then flows in a southeasterly direction to its confluence with White Clay Creek just south of Stanton, Delaware. The total distance from the mouth of Red Clay Creek to the headwaters of the East Branch is 20.7 miles, and to the headwaters of the West Branch, 23.7 miles.

The portion of Red Clay Creek covered by this report extends from its confluence with White Clay Creek upstream to the Delaware - Pennsylvania State Line, a distance of 12.6 stream miles. The entire study reach is located within New Castle County, Delaware. The principal tributaries within the study limits are Hyde Run and the Hoopes Reservoir Tributary. Plate 1 shows the Red Clay Creek watershed within the scope of this study.

The United States Geological Survey (U.S.G.S.) operates a recording stream gage on Red Clay Creek at Wooddale. The gage is located on the upstream side of Lancaster Pike bridge, Delaware State Route 48, and records runoff from a 47 square mile basin. It has been in operation since 1943. The previously published discharges at the gage for the period from 1960 to and including 1968 do not agree with data presented in this report since the stage discharge rating curve for this period is presently being revised by the U.S.G.S. However, the U.S.G.S. furnished a provisional corrected rating curve; and, accordingly, the revised published discharges, when available, should not vary greatly from the values used in this

study. Residents along the stream have been interviewed and newspaper files and historical documents have been searched for information concerning past floods. From these investigations and from studies of possible future floods on Red Clay Creek, the local flood situation, both past and future, has been determined.

The following paragraphs summarize the significant findings which are discussed in more detail in succeeding sections of this report:

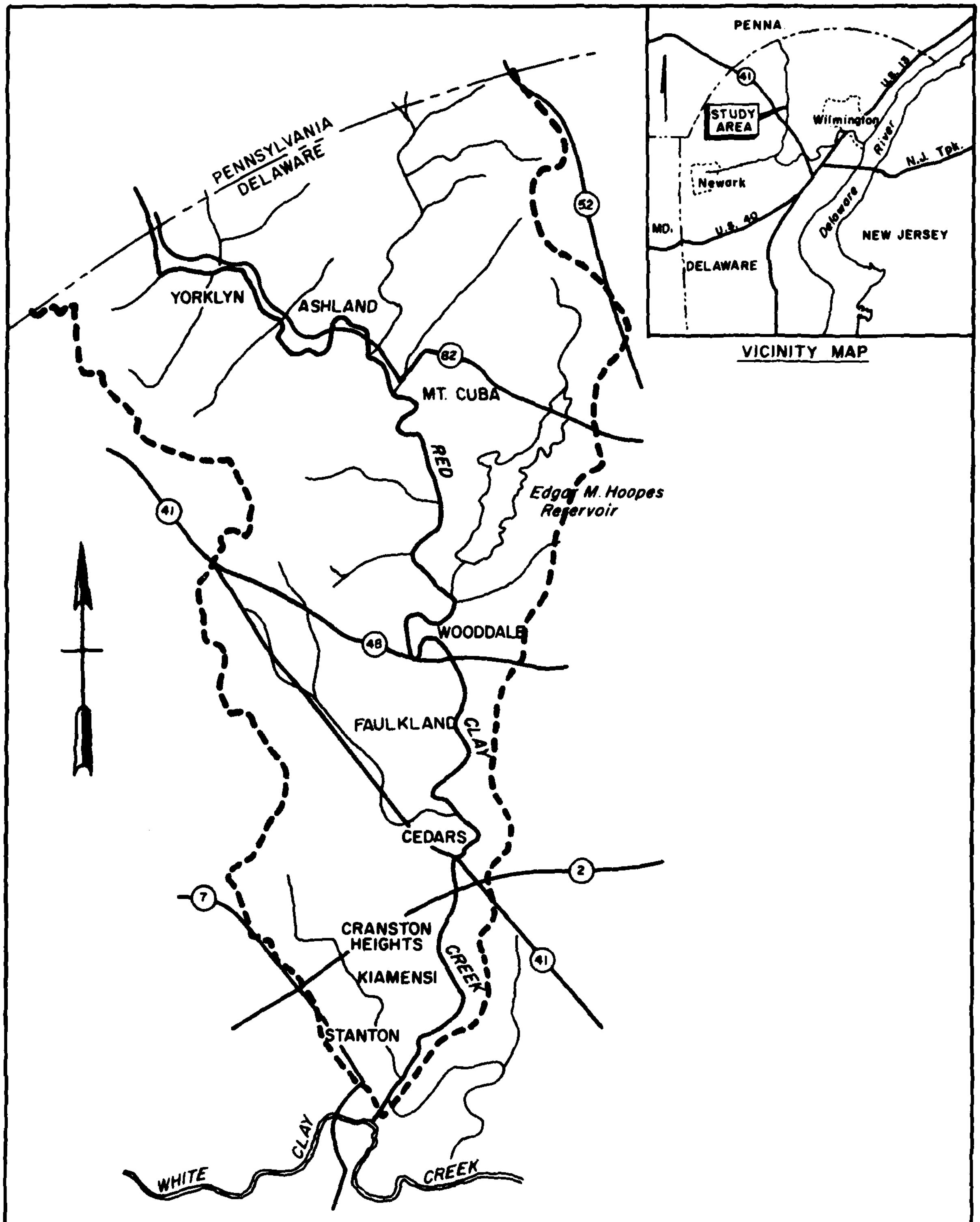
THE GREATEST FLOOD. The maximum known flood on Red Clay Creek for which only fragmentary information is available occurred on July 24, 1938. This flood was the result of a heavy rain on a watershed that had been saturated by three weeks of rain water.

* * *

THE GREATEST RECORDED FLOOD occurred on September 12, 1960 and resulted from Hurricane "Donna". This storm moved northward off the coast of New Jersey causing high winds and heavy rainfall (6 - 8 inches) in the study area. This flood reached an elevation of 91.39 feet, mean sea level datum (m.s.l.d.), at the Wooddale gage.

* * *

OTHER LARGE FLOODS. The second highest flood of record was that of July 28, 1969. This flood resulted from severe thunderstorms which dumped an average of 3 - 4 inches of rainfall on the Red Clay Creek Watershed. Although the precipitation was relatively low, the preceding period was unusually wet. The maximum total precipitation for the month of July was recorded in the year 1969 at many stations.



LEGEND

WATERSHED BOUNDARY

REACH COVERED BY STUDY

CORPS OF ENGINEERS, U.S. ARMY
PHILADELPHIA DISTRICT

RED CLAY CREEK
WATERSHED

SCALE IN FEET
5000 0 5000

FEBRUARY 1971

PLATE I

The third highest flood of record occurred on August 18 - 19, 1955 and was the result of Hurricane "Diane". Although only 3 to 4 inches of rainfall occurred during this storm within the study area, Hurricane "Connie" less than a week earlier had thoroughly saturated the soil and left the river stages above normal. The July 28, 1969 flood reached an elevation of 90.96 feet, m.s.l.d., at the Wooddale gage and the August 18 - 19, 1955 flood, an elevation of 89.84 feet, m.s.l.d., at the same location.

* * *

INTERMEDIATE REGIONAL FLOOD is a flood that has an average frequency of occurrence in the order of once in 100 years. It is determined from an analysis of floods on this stream and other streams in the same general area. The analysis indicates that the Intermediate Regional Flood would reach an elevation of 95.0 feet, m.s.l.d., at the Wooddale gage.

* * *

STANDARD PROJECT FLOOD determinations indicate that a flood could occur on Red Clay Creek that would be approximately 7.4 feet higher than the September 12, 1960 flood at the Wooddale gage. The Standard Project Flood is defined on page 30.

* * *

FLOOD DAMAGES that would result from the recurrence of major known floods would be substantial. More extensive damages would be caused by the occurrence of the Standard Project Flood because of its wider extent, greater depth and high velocity.

* * *

MAIN FLOOD SEASONS for this reach of Red Clay Creek are in the summer and winter months. Five of the ten highest recorded floods occurred during the months of July and August. However, major floods have occurred during all seasons of the year.

* * *

DURATION OF FLOODS. Stages can rise from normal flow to extreme flood peaks in a relatively short period of time. During the flood of July 1969, Red Clay Creek at the Wooddale gage had a maximum rate of rise of 2.6 feet per hour and the stream remained out of banks for 8.3 hours. During a Standard Project Flood at the same location, the stream would remain out of banks for 26 hours.

* * *

HAZARDOUS CONDITIONS would occur during large floods as a result of the rapidly rising stream, high velocities and deep flows.

* * *

FLOOD HEIGHTS that would be reached if the Intermediate Regional and Standard Project Floods occurred within the study area are shown in table 1. The table gives a comparison of these flood crests with the July 28, 1969 and September 12, 1960 floods.

* * *

TABLE 1

RELATIVE FLOOD HEIGHTS

RED CLAY CREEK

Location	Flood	Mileage Above Mouth	Estimated Peak Discharge cfs	Above July 1969 Flood Feet
Lancaster Pike (Del. Rt. 48)	July 28, 1969	4.96	4,500	-
	September 12, 1960	4.96	4,790	0.4
	Intermediate Regional	4.96	7,800	4.0
	Standard Project	4.96	22,600	7.8

GENERAL CONDITIONS

The flood plain of Red Clay Creek within the study area is predominantly narrow and wooded except for scattered areas within the central and upper portions and downstream near the mouth. These areas are industrially and residentially developed and have suffered severe flood damage in the past. They remain vulnerable to the still greater floods of the future.

Eleven dams are located on Red Clay Creek within the study area. The dams are relatively small and are either privately owned or used for industrial purposes. Since each dam has a very limited water-storage capacity, the total capability of reducing flood stages is therefore negligible. Photographs of some of the dams are shown in figures 1 and 2.

The watershed also includes the concrete dam of Hoopes Reservoir. Rising approximately 90 feet in vertical height, the structure impounds some 2.4 billion gallons of potable water for the City of Wilmington. The captured water at an elevation of 217 feet, m.s.l.d., has a surface area of 191 acres. Kept full by tapped water from the Brandywine Creek, the reservoir overtops its spillway most of the year.

The Hoopes Reservoir Tributary is only fed by a two square mile drainage area thereby having little effect on Red Clay Creek flooding. This single-purpose reservoir has no flood control capabilities. For the purpose of this study, the assumption was made that no major leaking of the dam would occur.

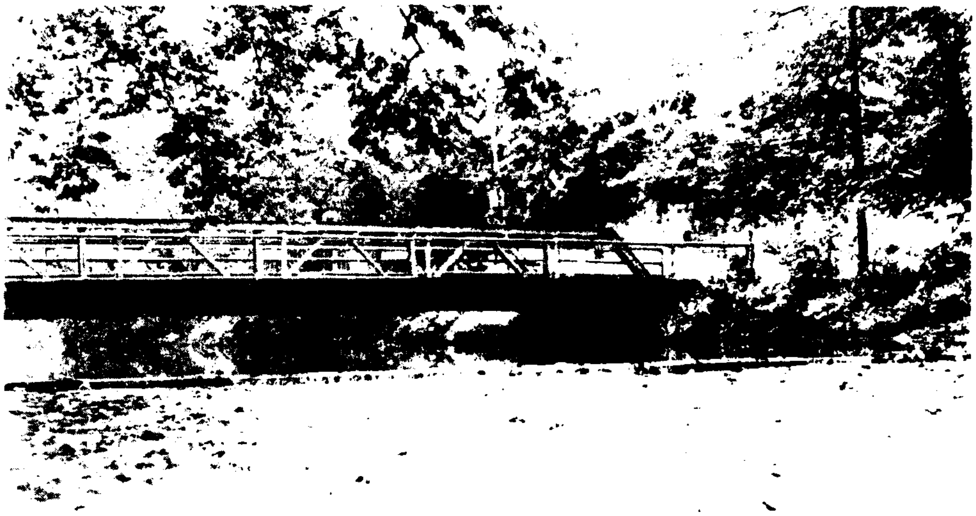


Figure 1.--DAMS ACROSS RED CLAY CREEK

Top view shows the dam downstream from the Yorklyn-Hockessin Road at Mile 11.6. The bottom view shows the concrete dam upstream from the timber trestle Baltimore and Ohio Railroad bridge at Mile 10.9.

Figure 2.--DAMS ACROSS RED CLAY CREEK

Top view shows the dam below the main line Baltimore and Ohio bridge at Mile 1.7. The bottom view shows Hoopes Reservoir which impounds water from a minor tributary of Red Clay Creek at Mile 6.5.

SETTLEMENT

The Red Clay Creek valley, settled for centuries by the Lenni-Lenape Tribe, is of historical interest. Dominance by the Lenni-Lenape Indian Nation over the Red Clay Creek territory ended in the 17th century with European expansion. Most traces of Indian civilization vanished through the westward movement and intermingling of peoples. The Europeans (of Swedish origin) converted the lands to farm lands and the water to sources of power.

In colonial days, many mills were located along the Delaware reach of Red Clay Creek. The change in elevation from Pennsylvania's hills to the lowlands of Delaware created a fast flowing current in Red Clay Creek suitable for operating mills of all types. There were grist mills, saw mills, paper mills, snuff mills and other water-powered industries of the times located along the creek. In modern times, the creek remains attractive to small industry and to the residential developments in the area.

FLOOD DAMAGE PREVENTION MEASURES

There are no existing flood control or related measures in the study area or upstream in the watershed, nor are there any flood plain regulations within the area.

FLOOD WARNING AND FORECASTING SERVICES

No specific flood warning or forecasting services are presently available in the area. Inhabitants of the area depend entirely upon the usual warnings issued through radio, television and the local press media.

THE STREAM AND ITS VALLEY

In the headwater reaches, the East and West Branches of Red Clay Creek flow through valleys formed by gently rolling hills. The flood plains are generally narrow (300 feet to 500 feet total width) and rural with both wooded and open areas. Through the lower section of Kennett Square, the East Branch flood plain is wide, flat and highly developed. The East Branch from Kennett Square downstream and the lower West Branch flow through narrow wooded valleys with steep side slopes. About 1.5 miles below the State Line in the industrialized area of Yorklyn, the flood plain widens, particularly on the right bank. Below this area, the stream again flows through extremely narrow valleys with extremely steep side slopes to the vicinity of Cedars, Delaware. From Cedars downstream through Stanton, Delaware, to the confluence with White Clay Creek, the valleys become wider and more open and the flood plain, more developed. Pertinent drainage areas in the study area are shown in table 2.

DEVELOPMENTS IN THE FLOOD PLAIN

In the upper reaches within the study limits, light development exists in the Yorklyn-Ashland region. Yorklyn has several small industries situated in vulnerable locations. The National Vulcanized Fibre Plant is one and has been flooded many times. In 1969, Plant #2 received 2-1/2 feet of water above the plant floor and had received 5-1/4 feet in 1938. The width of the flood plain at Yorklyn exceeds 1,600 feet.

TABLE 2

RED CLAY CREEK WATERSHED - DRAINAGE AREA

Mileage Above Mouth	Location	Drainage Area (Sq. Mi.) Tributary	Total
	West Branch		
19.4	Confluence with South Brook	-	5.5
19.4	South Brook	1.8	-
16.8	Confluence with Tributary Near Toughkenamon	-	9.8
16.8	Tributary Near Toughkenamon	2.6	-
15.1	Confluence with Bucktoe Creek	-	13.9
15.1	Bucktoe Creek	2.2	-
13.4	Confluence with East Branch	-	17.5
	East Branch		
18.5	Confluence with Tributary Near Red Lion	-	1.0
18.5	Tributary Near Red Lion	1.4	-
14.6	Confluence with Tributary Near Longwood	-	5.5
13.4	Confluence with West Branch	-	10.2
	Main Stem		
13.4	East-West Branch Confluence	-	27.7
12.6	Pennsylvania-Delaware State Boundary	-	28.4
11.6	Confluence with Tributary Near Hockessin	-	29.1
11.6	Tributary Near Hockessin	0.8	-
11.5	Confluence with Tributary Near Old Kennett Rd.	-	29.9
11.5	Tributary Near Old Kennett Rd.	1.2	-
9.1	Confluence with Tributary Near Burnt Mills	-	33.1
9.1	Tributary Near Burnt Mills	7.2	-

TABLE 2 (Continued)

RED CLAY CREEK WATERSHED - DRAINAGE AREA

Mileage Above Mouth	Location	Drainage Area (Sq. Mi.) Tributary	Total
	Main Stem (Cont'd)		
6.5	Confluence with Hoopes Reservoir Tributary	-	43.8
6.5	Hoopes Reservoir Tributary	2.0	-
4.9	U.S.G.S. Stream Gage 1-4800 (Wooddale)	-	47.0
3.3	Confluence with Hyde Run	-	48.1
3.3	Hyde Run	2.5	-
0.6	Confluence with Tributary Near Marshallton	-	52.2
0.6	Tributary Near Marshallton	1.7	-
0.0	Confluence with White Clay Creek	-	54.0
0.0	White Clay Creek Above Confluence with Red Clay Creek	158.0	-
-2.5	White Clay Creek Above Confluence with Christina River	-	217.0

NOTE: Many tributaries are unnamed and are described above by nearby communities or roads with which they are associated.

Below Ashland, the stream flows through an extremely narrow, steep, wooded valley past Mt. Cuba and south of the Lancaster Pike (Delaware Route 48) where it widens briefly. South of Faulkland Road (Mile 3.72) marks the start of extensive urbanization on the ground bordering the flood plain and scattered residences within.

In the lower reaches, south of Delaware Route 4 to the lower study limit, the plain is wide and flat with both commercial and residential structures vulnerable to major flooding.

BRIDGES ACROSS THE STREAM

Red Clay Creek is spanned by thirty-seven bridges in the 12.6 mile reach of the study area. Pertinent elevations for these structures and their relation to the Intermediate Regional and Standard Project Floods are shown on table 3.

Of the thirty-seven bridges, eleven are owned by the Baltimore and Ohio Railroad Company, six are located on major state routes, five are privately owned, two are foot bridges, and the remainder are state or local Government maintained.

Nine, one-track, timber trestle bridges of the Baltimore and Ohio Railroad Company cross the Red Clay Creek as both creek and rail wind through the valley. The chain of timber trestles are interrupted by a lone, single-span, steel truss, wooden deck bridge at Mile 9.61 and a two-track, single-span, steel truss with wooden deck at Mile 1.72.

The only railroad bridge that would be overtopped by the Intermediate Regional Flood is located at Mile 2.98 and its projected inundation is 1.1 feet. All of the bridges, except the one located at Mile 1.72, are inundated by the Standard Project Flood.

Delaware Route 4 crosses Red Clay Creek at Miles 0.80 and 0.82 upon twin, single-span, steel I-beam bridges with concrete decks and abutments. Both bridges would be inundated by the

Standard Project Flood. The Intermediate Regional Flood would inundate each bridge's road surface without completely overtopping their structures.

Delaware Route 2's high-level bridge offers abundant clearance for the passage of flood flows.

The old concrete arch bridge that carries Delaware Route 41 across Mile 2.78 would have its road surface submerged 1.7 feet by an Intermediate Regional Flood.

Lancaster Pike bridge at Mile 4.96 is a two-lane, two-span, concrete structure on concrete piers and abutments. This Delaware Route 48 bridge road surface would be under 3.1 feet of water during a Standard Project Flood.

Delaware Route 82 crosses the creek twice within the study area. Mile 9.40 is bridged by a single-span, concrete arch structure which would be inundated by the Standard Project Flood to a depth of 5.5 feet above the macadam road surface. The second bridge, at Mile 9.59, is a two-lane, single-span structure supported by steel girders on concrete abutments. The macadam road surface would barely escape the Intermediate Regional Flood but would be inundated 5.1 feet by the Standard Project Flood.

Worthy of special attention are two, scenic covered bridges. Near Hoopes Reservoir on a private road stands a covered bridge supported by steel I-beams. The second one is located at Mile 9.96 on the Ashland School Road - Wooddale Road.

As shown by the profiles on plates 10, 11 and 12, eleven highway bridges have their road surfaces inundated by the Intermediate

TABLE 3

BRIDGES ACROSS RED CLAY CREEK

Mileage Above Mouth	Identification	Stream Bed Elev. Feet	Floor Elev. Feet	Intermediate Regional Flood Crest Elev. Feet	Standard Project Flood Crest Elev. Feet	Underclearance Elev. Feet	Underclearance Elev. Above or (Below) Intermediate Regional Flood Feet	Underclearance Elev. Above or (Below) Standard Project Flood Feet
.80	Del. Rt. 4 - East Wilmington and Christina Turnpike	6.8	21.2	22.8	26.5	17.0	(5.8)	(9.5)
.82	Del. Rt. 4 - West	5.9	19.9	23.2	27.2	16.1	(7.1)	(11.1)
1.64	Kiamensi Rd.	15.7	31.5	28.3	32.9	28.7	0.4	(4.2)
1.72	Baltimore & Ohio R.R. (Mainline)	-	67.7	-	-	41.3	-	-
1.97	Old Capital Trail	29.5	42.5	42.5	46.0	39.1	(3.4)	(6.9)
2.07	Newport Rd.	30.4	41.6	42.9	46.6	40.2	(2.7)	(6.4)
2.20	Private Rd.	31.3	45.3	45.8	47.5	43.3	(2.5)	(4.2)
2.29	Private Rd.	32.6	47.8	45.8	48.4	45.6	(0.2)	(2.8)
2.44	Baltimore & Ohio R.R.	39.2	54.4	51.1	55.9	50.9	(0.2)	(5.0)
2.50	Del. Rt. 2 - Robert Kirkwood Highway	-	88.3	-	-	87.9	-	-
2.78	Del. Rt. 41 - Newport and Gap Rds.	43.6	58.8	60.5	66.5	56.0	(4.5)	(10.5)

TABLE 3 (Continued)

BRIDGES ACROSS RED CLAY CREEK

Mileage Above Mouth	Identification	Stream Bed Elev.	Floor Elev.	Intermediate Regional Flood Crest Elev.	Standard Project Flood Crest Elev.	Underclearance Elev.	Underclearance Elev. Above or (Below) Intermediate Regional Flood	Underclearance Elev. Above or (Below) Standard Project Flood
		Feet	Feet	Feet	Feet	Feet	Feet	Feet
2.84	Foot bridge	46.0	60.2	61.5	67.0	58.7	(2.8)	(8.3)
2.95	Greenbank Rd.	46.2	60.2	62.4	68.0	58.1	(4.3)	(9.9)
2.98	Baltimore & Ohio R.R.	46.8	62.4	63.5	68.5	59.2	(4.3)	(9.3)
3.54	Baltimore & Ohio R.R.	60.3	74.5	71.5	78.7	71.0	(0.5)	(7.7)
3.72	Faulkland Rd.	63.0	76.7	76.0	81.3	73.1	(2.9)	(8.2)
4.42	Baltimore & Ohio R.R.	77.3	94.5	90.2	96.9	90.2	0	(6.7)
4.92	Foot bridge (Company Golf Course	81.8	90.8	92.3	98.6	88.9	(3.4)	(9.7)
4.96	Del. Rt. 48 - Lancaster Pike	81.5	95.7	95.0	98.8	92.3	(2.7)	(6.5)
5.08	Baltimore & Ohio R.R.	83.3	101.3	95.9	103.9	97.8	1.9	(6.1)
6.03	Baltimore & Ohio R.R.	90.5	106.3	102.9	110.8	102.8	(0.1)	(8.0)
6.09	Private Rd. (Covered Bridge)	90.1	108.2	103.5	114.7	103.8	0.3	(10.9)
6.94	Barley Mill Rd.	101.9	114.9	116.0	122.4	112.9	(3.1)	(9.5)
7.81	Hillside Mill Rd.	110.0	124.0	122.8	128.2	120.4	(2.4)	(7.8)
8.05	Baltimore & Ohio R.R.	113.7	129.9	124.9	131.6	126.4	1.5	(5.2)

TABLE 3 (Continued)

BRIDGES ACROSS RED CLAY CREEK

Mileage Above Mouth	Identification	Stream Bed Elev. Feet	Floor Elev. Feet	Intermediate Regional Flood Crest Elev. Feet	Standard Project Flood Crest Elev. Feet	Underclearance Elev. Feet	Underclearance Elev. Above or (Below): Intermediate Regional Flood Feet	Underclearance Elev. Above or (Below): Standard Project Flood Feet
8.39	Baltimore & Ohio R.R.	120.0	134.5	131.9	136.1	131.0	(0.9)	(5.1)
9.14	Private Rd.	128.3	141.7	141.1	148.7	139.9	(1.2)	(7.8)
9.40	Del. Rt. 82	132.5	145.1	144.2	150.6	143.3	(0.9)	(7.3)
9.59	Del. Rt. 82	134.3	148.5	148.4	153.6	145.9	(2.5)	(7.7)
9.61	Baltimore & Ohio R.R.	135.7	149.9	149.7	153.8	146.2	(3.5)	(7.6)
9.96	Ashland School Rd. - Wooddale Rd. (Covered Bridge)	139.4	150.1	150.4	154.8	147.6	(2.8)	(7.2)
10.48	Sharpless Rd.	144.7	158.9	153.5	156.9	158.6	5.1	1.7
10.93	Baltimore & Ohio R.R.	152.4	167.2	164.0	169.0	163.5	(0.5)	(5.5)
11.34	Baltimore & Ohio R.R.	164.9	176.4	175.6	180.3	173.8	(1.8)	(6.5)
11.64	Yorklyn Rd.	169.3	179.3	180.3	181.2	177.1	(3.2)	(4.1)
12.01	Benge Rd.	171.8	184.6	183.5	187.8	183.6	0.1	(4.2)
12.21	Private Rd.	174.1	185.8	188.2	191.2	185.0	(3.2)	(6.2)

NOTE: Floor elevations for railroad bridges were taken at top of rail.

Regional Flood and twenty-two, by the Standard Project Flood. Table 3 gives relative flood heights for all bridges. Photographs of selected bridges across Red Clay Creek appear in Figures 3 and 4.

OBSTRUCTIONS TO FLOOD FLOW

With the exception of the bridges, there are no significant obstructions to flood flows within the study area. The eleven low dams located within the study area are not considered to be obstructions to flood flows. However, it has been assumed that there would be no accumulation of debris to clog the bridge openings or dam spillways and that no structure failures would occur. Both clogging or bridge failure would cause more extensive flooding upstream than would otherwise occur.

FLOOD SITUATION

FLOOD RECORDS

The U.S.G.S. has maintained a gaging station on Red Clay Creek near Wooddale. Continuous records are available since 1943. Furnished data from 1960 to 1968 inclusive have been revised in accordance with a provisional rating curve supplied by the U.S.G.S. to this office. Data for this stream gage is given in table 4. Supplemental data were obtained through interviews with local residents and by searching newspaper files for flood heights and dates of flooding.

FLOOD STAGES AND DISCHARGES

Crest stages and discharges for floods above 1,200 cubic feet per second at the U.S.G.S. gage at Wooddale, Delaware, are shown

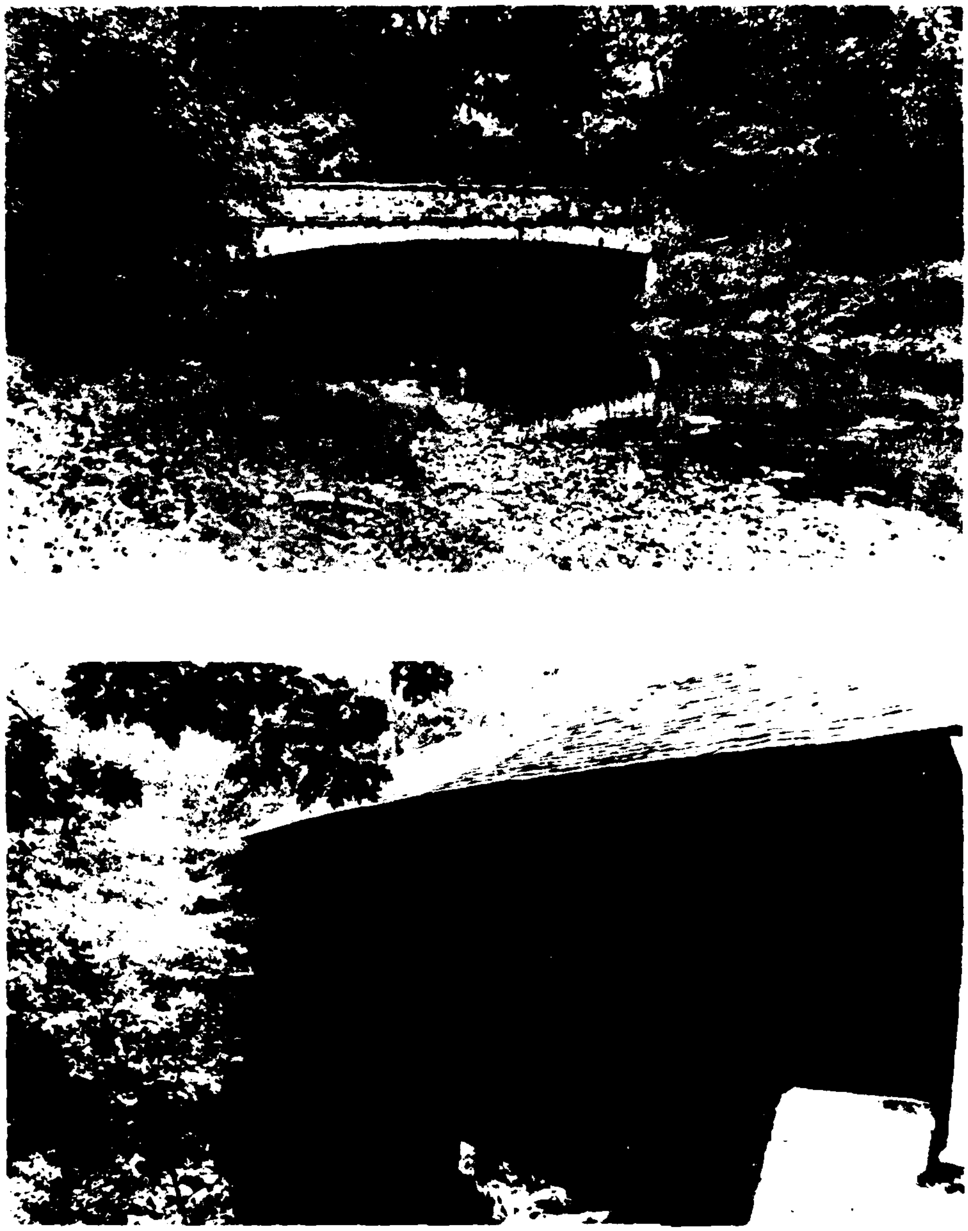


Figure 3.--BRIDGES ACROSS RED CLAY CREEK

Top view shows the upstream side of a private, stone arch bridge at Mile 9.1. Bottom view shows the downstream side of a covered bridge supported by steel beams at Mile 6.1.

Figure 4.--BRIDGES ACROSS RED CLAY CREEK

Top view shows the downstream view of the Lancaster Pike reinforced concrete bridge. The U.S.G.S. stream gage is located on the upstream side at Mile 5.0. Bottom view shows the wooden foot bridge near the Greenbank Mill at Mile 2.8.

in table 4. The ten highest known floods in order of magnitude as registered on the Red Clay Creek gage at Wooddale are listed in table 5.

TABLE 4

RED CLAY CREEK AT WOODDALE, DELAWARE

CREST ELEVATIONS FOR FLOODS ABOVE 1,200 CUBIC FEET PER SECOND

The table includes all floods between 1943 to the present having a flood crest above 1,200 cubic feet per second at the U.S.G.S. gaging station at the Lancaster Pike High Bridge (Delaware Rt. 48) in Wooddale, Delaware; Drainage Area = 47.0 square miles; Datum of Gage = 81.46 feet above mean sea level datum, USC & GS 1929 General Adjustment Datum. Discharges from September 12, 1960 on reflect the provisional rating curve supplied by the U.S.G.S.

Date of Crest	Gage Height		Discharge
	Stage Feet	Elevation Feet	cfs
May 12, 1943	5.52	86.98	1,730
June 27, 1943	5.14	86.60	1,490
July 11, 1943	4.85	86.31	1,310
January 4, 1944	5.38	86.84	1,670
March 13, 1944	5.02	86.48	1,430
January 1, 1945	5.80	87.26	1,910
July 2, 1945	4.77	86.23	1,310
July 5, 1945	5.02	86.48	1,430
July 18, 1945	7.29	88.75	2,810
August 1, 1945	4.79	86.25	1,310

TABLE 4 (Continued)

Date of Crest	Gage Height Stage Feet	Gage Height Elevation Feet	Discharge cfs
August 6, 1945	4.75	86.21	1,310
September 18, 1945	5.70	87.16	1,850
June 2, 1946	6.19	87.65	2,150
July 23, 1946	6.76	88.22	2,510
May 1, 1947	6.07	87.53	2,030
November 8, 1947	4.91	86.37	1,370
February 14, 1948	5.50	86.96	1,730
February 17, 1948	4.99	86.45	1,430
February 28, 1948	5.20	86.66	1,550
June 19, 1948	5.24	86.70	1,550
December 30, 1948	5.80	87.26	1,880
January 28, 1949	5.50	86.96	1,730
March 23, 1949	5.56	87.02	1,790
August 3, 1950	6.92	88.38	2,570
September 11, 1950	5.42	86.88	1,670
November 25, 1950	7.20	88.66	2,740
February 7, 1951	5.11	86.57	1,330
November 7, 1951	5.82	87.28	1,770
December 21, 1951	6.85	88.31	2,500
February 4, 1952	5.60	87.06	1,630
March 11, 1952	5.89	87.35	1,820
June 1, 1952	4.88	86.34	1,200
July 9, 1952	7.21	88.67	2,750
November 22, 1952	5.16	86.62	1,370
December 11, 1952	5.70	87.16	1,690
January 24, 1953	5.85	87.31	1,800
December 14, 1953	4.98	86.44	1,260
February 7, 1955	6.03	87.49	1,920
August 13, 1955	7.21	88.67	2,750
August 18, 1955	8.38	89.84	3,650

TABLE 4 (Continued)

Date of Crest	Gage Height Stage Feet	Gage Height Elevation Feet	Discharge cfs
March 14, 1956	4.91	86.37	1,220
June 1, 1956	5.22	86.68	1,400
July 21, 1956	5.42	86.88	1,520
November 2, 1956	6.88	88.34	2,520
January 22, 1958	5.25	86.71	1,420
January 25, 1958	5.30	86.76	1,450
February 28, 1958	5.90	87.36	1,830
April 6, 1958	5.28	86.74	1,440
June 11, 1958	6.67	88.13	2,370
August 16, 1958	5.02	86.48	1,280
August 25, 1958	4.97	86.43	1,250
June 2, 1959	6.17	87.63	2,020
February 19, 1960	5.18	86.64	1,380
September 12, 1960	9.93	91.39	4,790
April 13, 1961	5.06	86.52	1,340
February 26, 1962	5.28	86.74	1,500
March 12, 1962	5.67	87.13	1,770
February 12, 1963	5.26	86.72	1,480
March 6, 1963	5.13	86.59	1,390
January 9, 1964	6.86	88.32	2,620
February 8, 1965	5.92	87.38	1,920
February 13, 1966	7.00	88.46	2,730
March 7, 1967	7.23	88.69	2,910
July 11, 1967	5.52	86.98	1,660
August 10, 1967	6.40	87.86	2,280
December 3, 1967	5.24	86.70	1,470
January 14, 1968	5.53	86.99	1,670
March 13, 1968	4.89	86.35	1,220
March 18, 1968	4.93	86.39	1,250
May 28, 1968	4.80	86.26	1,160
July 28, 1969	9.50	90.96	4,500

TABLE 5

HIGHEST TEN RECORDED FLOODS IN ORDER OF MAGNITUDE
RED CLAY CREEK AT WOODDALE, DELAWARE

Datum of Gage = 81.46 feet above mean sea level datum

Order No.	Date of Crest	Gage Height Stage Feet	Gage Height Elevation Feet *	Estimated Peak Discharge cfs
1	September 12, 1960	9.93	91.39	4,790
2	July 28, 1969	9.50	90.96	4,500
3	August 18, 1955	8.38	89.84	3,650
4	March 7, 1967	7.23	88.69	2,910
5	July 18, 1945	7.29	88.75	2,810
6	July 9, 1952	7.21	88.67	2,750
7	August 13, 1955	7.21	88.67	2,750
8	November 25, 1950	7.20	88.66	2,740
9	February 13, 1966	7.00	88.46	2,730
10	January 9, 1964	6.86	88.32	2,620

* Mean Sea Level Datum, Sandy Hook, New Jersey, 1929 General Adjustment.

FLOOD OCCURRENCES

All discharges listed in table 4 are flows greater than bankfull at the gage. On Red Clay Creek, floods have occurred 70 times in the 26-year period shown. This is an average of greater than two floods per year, with seven occurrences of overbank flow in two years, 1945 and 1958.

DURATION AND RATE OF RISE

Duration of flooding and rate of rise from normal flow to extreme flood peaks will vary with each individual flood. A comparison of the largest flood, dated September 12, 1960, and the second largest flood, dated July 28, 1969, shows that the larger flood had a maximum rate of rise at 0.8 foot per hour and a duration of 14.3 hours above critical stage. The smaller flood had a shorter duration of 8.3 hours but had a quicker rate of rise at 2.6 feet per hour. Plate 3 shows the discharge hydrograph for the Red Clay Creek at Wooddale for the September 12, 1960 and July 28, 1969 floods.

VELOCITIES

During a Standard Project Flood on the Red Clay Creek, velocities would range up to 10.2 feet per second in the channel and up to 4.3 feet per second in some overbank areas. Considerably higher velocities could be expected at bridges or other constrictions.

FLOODED AREAS, FLOOD PROFILES AND CROSS SECTIONS

Plates 6, 7, 8 and 9 show the approximate areas along the Red Clay Creek that would be inundated by the Intermediate Regional

and Standard Project Floods. The actual limits of these overflow areas may vary somewhat from those shown on the map because the 10-foot contour interval and scale of the map do not permit precise plotting of the flooded area boundaries.

High water profiles indicating the Intermediate Regional and Standard Project Floods are shown on plates 10, 11 and 12 and their derivation is discussed in succeeding portions of this report.

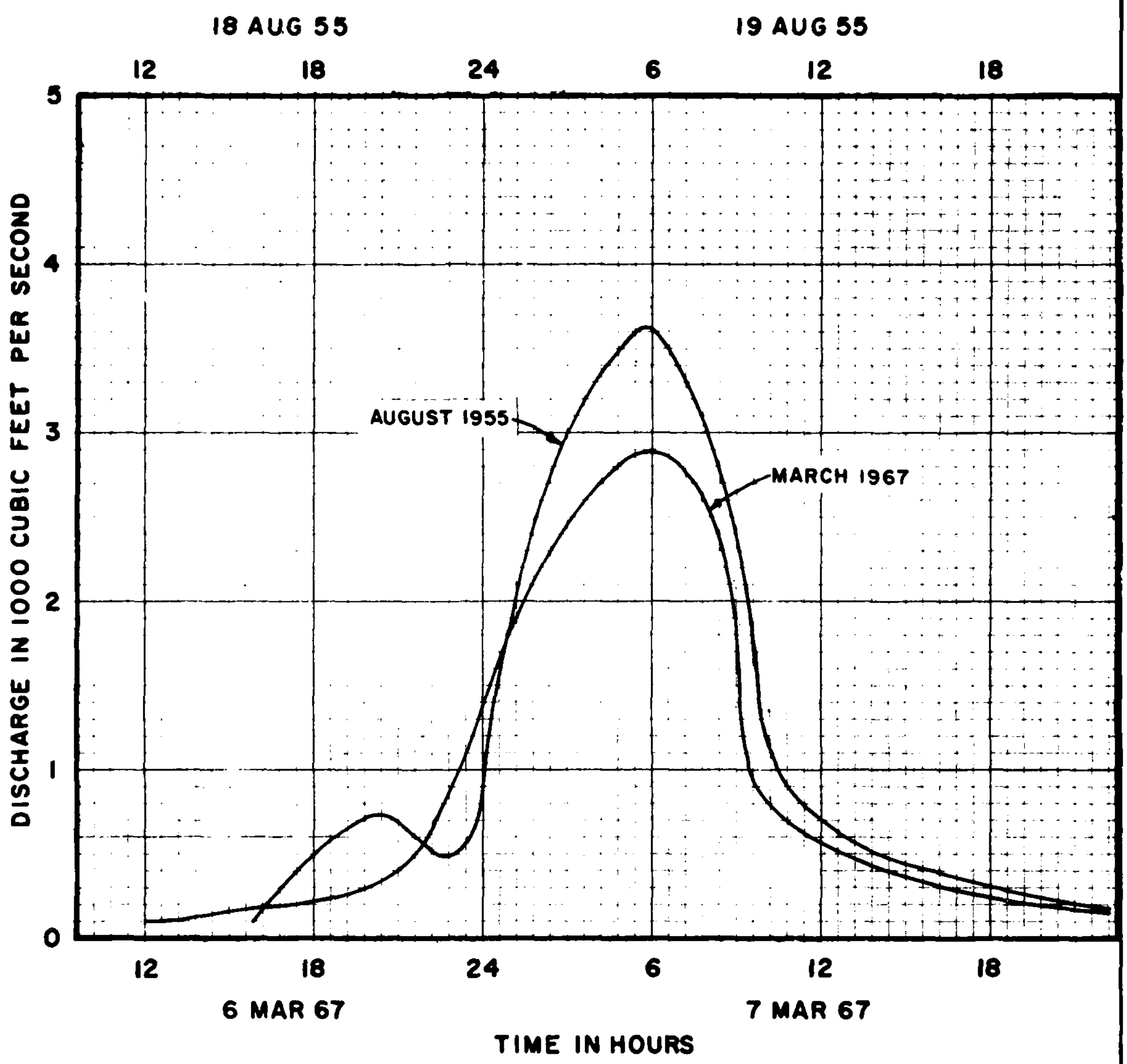
Plate 13 shows cross sections that are typical of the 29 sections obtained along Red Clay Creek within the study area. The locations of all sections are shown on plates 6 through 9. The elevations and extent of overflow of the Intermediate Regional and Standard Project Floods are indicated on these cross sections.

FLOOD DESCRIPTIONS

JULY 24, 1938

The greatest flood occurring on Red Clay Creek in the twentieth century was that on July 24, 1938. Statistics are not listed for this flood since no accurate information is available.

Weather statistics of July 23rd showed that the monthly rainfall had already set a record. The weatherman calculated that four million tons of rain had fallen on Wilmington in twenty-two days. The wetness had doomed some local farm crops but bumper crops of watermelons, cantaloupes, cucumbers, sweet potatoes and tomatoes were expected that year.



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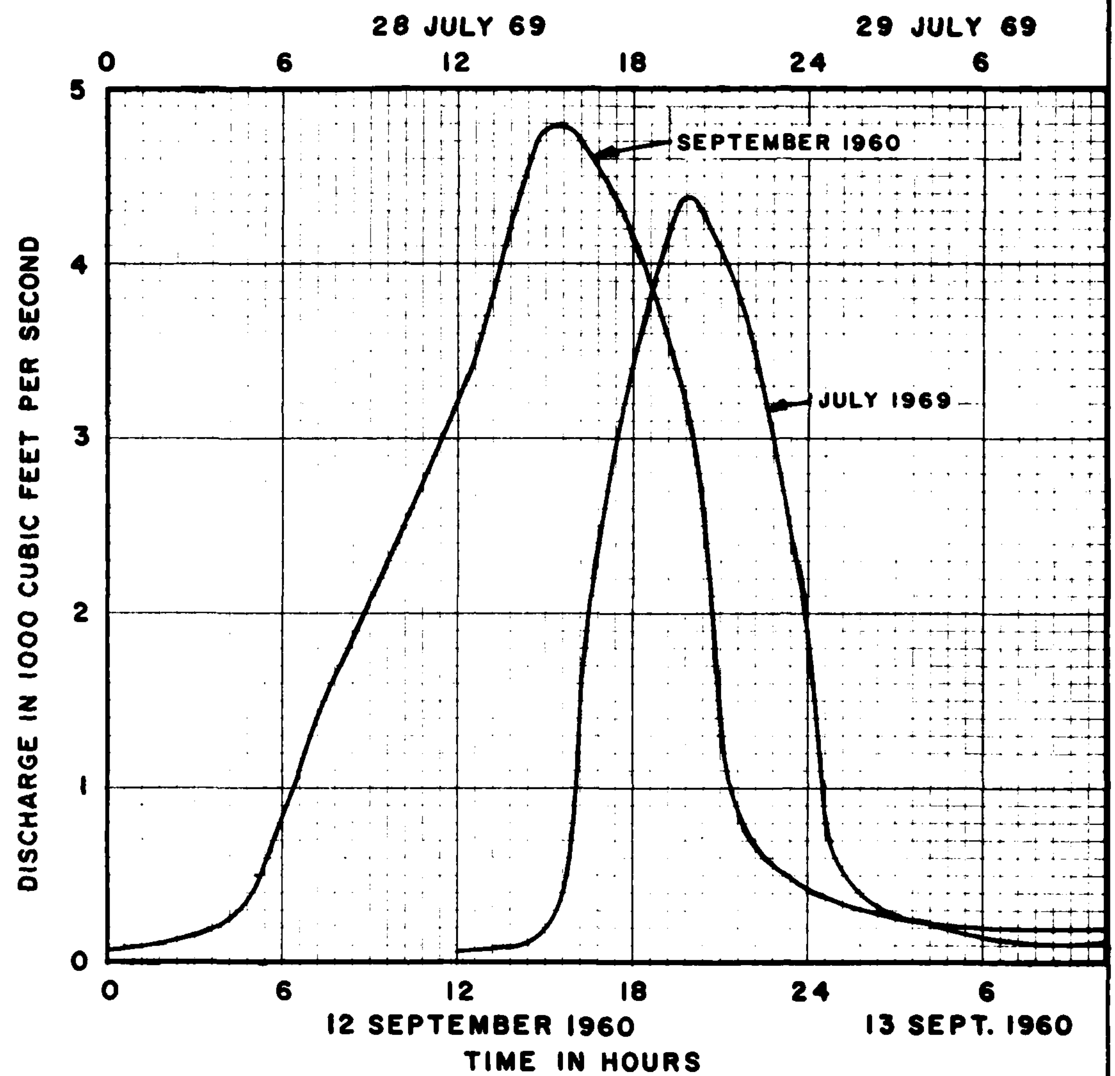
PHILADELPHIA DISTRICT

DISCHARGE HYDROGRAPHS

RED CLAY CREEK
AT WOODDALE, DELAWARE
FEBRUARY 1971



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PHILADELPHIA DISTRICT

DISCHARGE HYDROGRAPHS

RED CLAY CREEK
AT WOODDALE, DELAWARE

FEBRUARY 1971

PLATE 3

On July 24th the rains came. The ground, swollen to capacity like a bloated sponge, shed the rains directly into the stream. The following damages are as listed:

1. Sharpless Road, near Hockessin, was inundated 6 to 8 feet when the Red Clay Creek changed course.

2. A change in course eliminated a bend in the creek and left the mill pond and race of George W. Pusey's flour mill without water to generate power.

3. The road from Yorklyn to Ashland was demolished.

4. Three covered bridges were battered, the one from Yorklyn to Ashland was washed away.

5. Marshall Brothers, Inc., Plant, Yorklyn, was inundated to 4 feet, 9 inches. Much machinery was damaged and seven million pounds of baled rags were damaged beyond salvage.

6. Marshallton was the hardest hit residential area. There the overflowing water inundated homes to the depth of 10 feet.

SEPTEMBER 12, 1960

The maximum recorded flood on the Red Clay Creek occurred on September 12, 1960, a result of Hurricane "Donna". Donna brought 6 to 8 inches of rain throughout the watershed. The U.S.G.S. gage on the Lancaster Pike, State Route 48, indicated that the 4,790 cubic feet per second (CFS) discharge caused a stage height of 9.93 feet. The flood reached an elevation of 91.39 feet, m.s.l.d., which is about 0.9 foot below the Lancaster Pike bridge underclearance.

Damage to the watershed was minor compared to the destruction in neighboring sections of the state and the northeast coast.

JULY 28, 1969

Flooding which occurred on July 28, 1969 constituted the second highest rise of water recorded by the Lancaster Pike gage at Wooddale. Records indicate a peak discharge of 4,500 cubic feet per second with a stage height of 9.5 feet. The water surface elevation was 90.96 feet, m.s.l.d., or 0.43 foot below the 1960 flood.

Damages from this flood were more extensive than that of September 1960 due to development in the flood plain. The bridge at Brandywine Springs State Park was endangered. Along Old Public Road near Hockessin Hills, some homes suffered foundation damage from a swollen tributary of the Red Clay Creek.

The Haveg Industries, Inc., suffered damages to their electrical equipment in Building 24. Many of their electric motors had to be dismantled and baked, while others were rewound. Damages also included a full day's lost time cleaning up and several days' work at 40% production.

FUTURE FLOODS

This section of the report deals with the Standard Project Flood and the Intermediate Regional Flood on Red Clay Creek within the study limits in New Castle County, Delaware, and some of the hazards of great floods. The Standard Project Flood represents a reasonable upper limit of expected flooding in the study area. The Intermediate Regional Flood may reasonably be expected to occur more frequently, although it will not be as severe as the infrequent Standard Project Flood.

Large floods have been experienced in the past on streams with similar geographical and physiographical characteristics as those found in the study area. This same heavy flooding could occur over the Red Clay Creek watershed. In this event, floods would result in the study area comparable in size with those experienced on neighboring streams. It was therefore necessary, in connection with the determination of future floods which may occur in this study area, to consider storms and floods that have occurred in a region where the topography, watershed cover, and physical characteristics are similar.

DETERMINATION OF INTERMEDIATE REGIONAL FLOOD

The Intermediate Regional Flood is defined as a flood having an average frequency of occurrence in the order of once in 100 years at a designated location, although the flood may occur in any year. Probability estimates are based on statistical analyses of stream flow records available for the watershed under study. However, limitations in such records usually require the analysis of rainfall and runoff characteristics on a regional rather than a watershed basis. The Intermediate Regional Flood is considered a major flood, although less severe than the Standard Project Flood.

In determining the Intermediate Regional Flood for the Red Clay Creek, statistical studies were made using the yearly record of known flood data of the U.S.G.S. gaging station at Wooddale, Delaware.

Results of the study indicate that the Intermediate Regional Flood on the Red Clay Creek at the gage location at the Lancaster

Pike highway bridge in Wooddale (5.0 miles above the mouth of Red Clay Creek) would have a peak discharge of 7,800 cubic feet per second, and would be 3.6 feet higher than the September 12, 1960 flood at this location. A more detailed listing of computed peak discharges of the Intermediate Regional Flood for this stream is shown in tables 1 and 6.

TABLE 6

INTERMEDIATE REGIONAL FLOOD
PEAK DISCHARGES ON RED CLAY CREEK

Location	River Mile	Drainage Area Sq. Mi.	Discharge cfs
Mouth	0	54.0	8,700
Gage (1-4800) At Wooddale	4.96	47.0	7,800
Upper Study Limit (Delaware - Pennsylvania State Line)	12.60	28.4	5,700

DETERMINATION OF STANDARD PROJECT FLOOD

The U. S. Army Corps of Engineers, in cooperation with the U. S. Weather Bureau, has made broad and comprehensive studies and investigations based on past records of experienced storms and floods and has developed generalized procedures for estimating the flood potential of streams. The procedures have been used in determining the Standard Project Flood. This flood is defined as the largest flood that can reasonably be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical region involved. Only on rare occasions has a specific stream experienced

the largest flood that is likely to occur. However, it is a commonly accepted fact that, in practically all cases, a more severe flood than any that have occurred in the past can and probably will occur.

A Standard Project Flood estimate has been made for Red Clay Creek within the study limits. The rainfall for this flood was determined according to the procedures set forth in the Corps of Engineers EM 1112-2-1411 (Engineering Manual). Peak discharges for the Standard Project Flood at selected locations within the study area are shown in tables 1 and 7. The Standard Project Flood hydrographs are shown on plate 4.

TABLE 7

STANDARD PROJECT FLOOD

PEAK DISCHARGES ON RED CLAY CREEK

Location	River Mile	Drainage Area Sq. Mi.	Discharge cfs
Mouth	0	54.0	24,200
Gage (1-4800) At Wooddale	4.96	47.0	22,600
Upper Study Limit (Delaware - Pennsylvania State Line	12.60	28.4	14,200

FREQUENCY

It is not practical to assign a frequency to the Standard Project Flood. The occurrence of such a flood would be a rare event; however, it could occur in any year.

POSSIBLE LARGER FLOODS

Floods larger than the Standard Project Flood are possible. However, the combination of factors that would be necessary to

produce a flood of this magnitude would seldom occur. The consideration of such a severe flood is of greater importance in some areas than in others but it should not be overlooked in the study of any flood area.

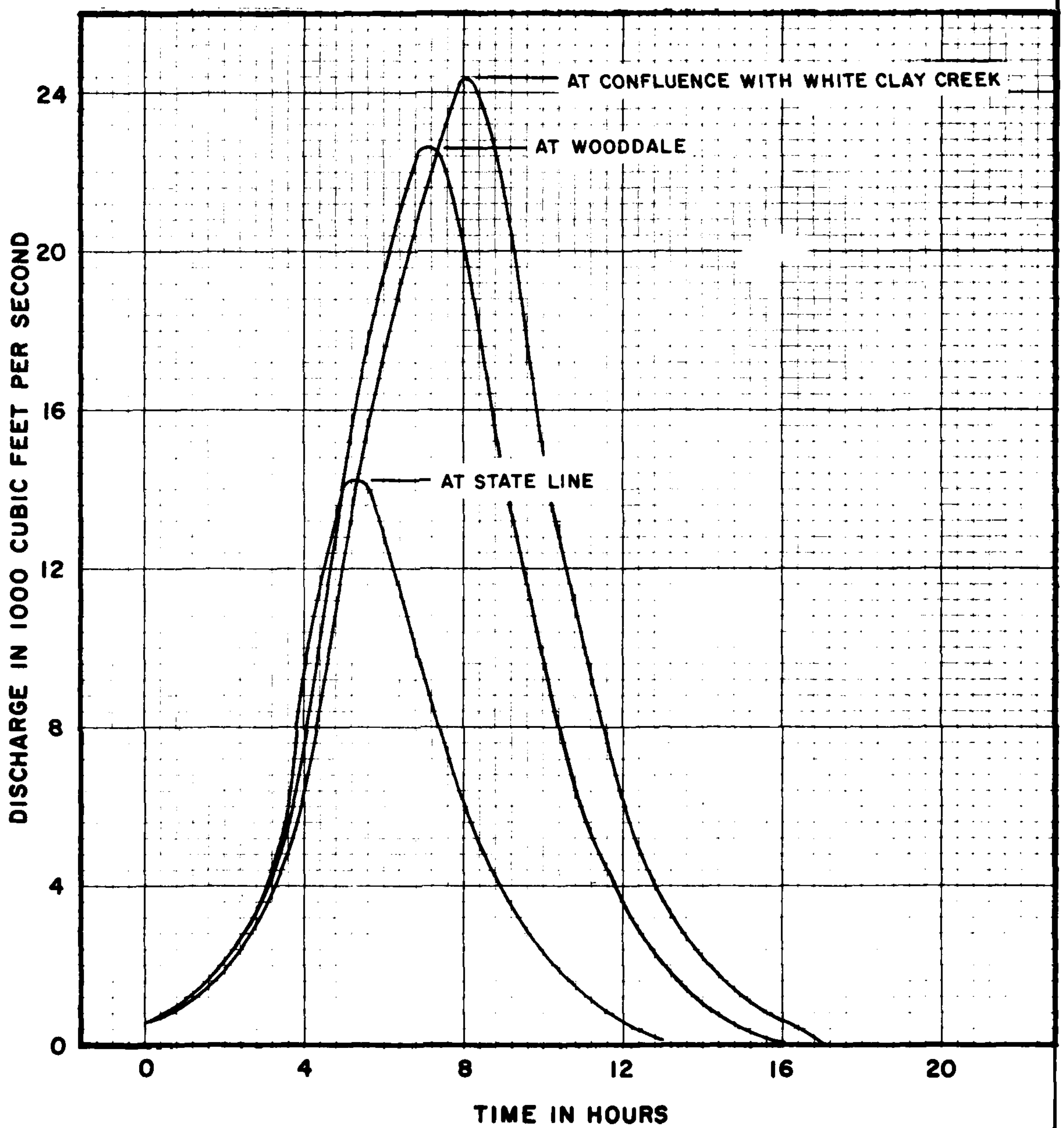
AREAS FLOODED AND HEIGHTS OF FLOODING

The areas along Red Clay Creek within the study limits that would be flooded by the Intermediate Regional and Standard Project Floods are shown on plates 6 through 9. The depths of flow can be estimated from the high water profiles shown on plates 10, 11 and 12.

The profiles for the stream were computed by using stream characteristics determined from profiles, topographic maps and valley cross sections surveyed during August 1969. The elevations shown on the profiles and the overflow areas shown on the maps have been determined with an accuracy consistent with the purposes of this study and the accuracy of the basic data.

The profiles of the Intermediate Regional Flood and the Standard Project Flood depend in part on the degree of destruction or clogging of various bridges during the flood. As it is nearly impossible to forecast these events, it was assumed that all bridge structures would stand and that no significant clogging would occur.

Figures 5 and 6 show the heights that would be reached by the Intermediate Regional and Standard Project Floods at selected locations within the study area.



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PHILADELPHIA DISTRICT
STANDARD PROJECT FLOOD
HYDROGRAPH
RED CLAY CREEK
NEW CASTLE COUNTY, DELAWARE
FEBRUARY 1971

PLATE 4

Figure 5.--FLOOD HEIGHTS ALONG RED CLAY CREEK

Top view is the National Vulcanized Fibre Plant at Yorklyn, Mile 11.6. Bottom view shows the historic Greenbank Mill at Mile 2.8. The Standard Project Flood and Intermediate Regional Flood heights that would be reached at these locations are shown by the arrows.

Figure 6.--FLOOD HEIGHTS ALONG RED CLAY CREEK

The arrows in the view above indicate the heights that would be attained by the Intermediate Regional and Standard Project Floods at Mile 1.97 along the Old Capital Trail.

VELOCITIES, RATES OF RISE AND DURATION

Water velocities during floods depend largely on the size and shape of the cross section, condition of the stream and the bed slope, all of which vary on different streams and at different locations on the same stream. Velocities in the range of 4 to 10 feet per second or higher are not uncommon in large floods.

Table 8 lists the maximum velocities that would occur in the main channel and overbank areas of Red Clay Creek during the Intermediate Regional and Standard Project Floods.

Table 9 lists the total rise above normal flow to the crest of flood, the maximum rates of rise, and the duration above bankfull stage for several past floods at the Wooddale gaging station.

These rates of rise and high stream velocities in combination with deep, long-duration flooding would create a hazardous situation in developed areas. Velocities greater than three feet per second combined with depths of three feet or more are generally considered hazardous.

TABLE 8

MAXIMUM VELOCITIES

RED CLAY CREEK

Location	River Mile	Intermediate Regional Flood Velocities Channel Ft. per Sec.	Intermediate Regional Flood Velocities Overbank Ft. per Sec.	Standard Project Flood Velocities Channel Ft. per Sec.	Standard Project Flood Velocities Overbank Ft. per Sec.
Near Mouth	0.65	5.3	1.6	10.0	3.1
Gage (1-4800) At Wooddale	4.96	6.6	3.2	10.0	4.0
Cross Section #27	11.70	6.3	2.3	10.2	4.3

TABLE 9

RATES OF RISE AND DURATION OF FLOODS

RED CLAY CREEK

AT WOODDALE, DELAWARE

Flood	Height of Rise * Feet	Time of Rise Hrs.	Maximum Rate of Rise Ft. per Hr.	Duration Above Bankfull Hrs.
September 12, 1960	6.7	11.5	0.8	14.3
July 28, 1969	6.3	3.0	2.6	8.3
August 18, 1955	4.6	8.0	1.8	9.9
March 7, 1967	4.2	10.0	0.7	9.8

* Rise in feet above normal flow.

GLOSSARY OF TERMS

Flood. An overflow of lands not normally covered by water and that are used or usable by man. Floods have two essential characteristics: the inundation of land is temporary; and the land is adjacent to an inundated by overflow from a river or stream or an ocean, lake, or other body of standing water.

Normally a "flood" is considered as any temporary rise in stream flow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land area, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, rise of ground water coincident with increased stream flow, and other problems.

Flood Crest. The maximum stage or elevation reached by the waters of a flood at a given location.

Flood Peak. The maximum instantaneous discharge of a flood at a given location. It usually occurs at or near the time of the flood crest.

Flood Plain. The relatively flat area or lowlands adjoining the channel of a river, stream or watercourse or ocean, lake, or other body of standing water, which has been or may be covered by flood water.

Flood Profile. A graph showing the relationship of water surface elevation to location, the latter generally expressed as distance above mouth for a stream of water flowing in an open channel. It is generally drawn to show surface elevation for the crest of a specific flood, but may be prepared for conditions at a given time or stage.

Flood Stage. The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.

Head Loss. The effect of obstructions, such as narrow bridge openings or buildings that limit the area through which water must flow, raising the surface of the water upstream from the obstruction.

Intermediate Regional Flood. A flood having an average frequency of occurrence in the order of once in 100 years although the flood may occur in any year. It is based on statistical analyses of stream flow records available for the watershed and analyses of rainfall and runoff characteristics in the general region of the watershed.

Left Bank. The bank on the left side of a river, stream, or watercourse, looking downstream.

Low Steel (or Underclearance). See "Underclearance".

Right Bank. The bank on the right side of a river, stream, or watercourse, looking downstream.

Standard Project Flood. The flood that may be expected from the most severe combination of meteorological and hydrological conditions that is considered reasonably characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations. Peak discharges for these floods are generally about 40% to 60% of the Probable Maximum Floods for the same basins. Such floods, as used by the Corps of Engineers, are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

Underclearance. The lowest point of a bridge or other structure over or across a river, stream, or watercourse that limits the opening through which water flows. This is referred to as "low steel" in some regions.

AUTHORITY, ACKNOWLEDGMENTS AND INTERPRETATION OF DATA

This report has been prepared in accordance with the authority granted by Section 206 of the Flood Control Act of 1960 (PL 86-645), as amended.

* * *

Assistance and cooperation of the U. S. Weather Bureau, U. S. Geological Survey, U. S. Department of Agriculture - Soil Conservation Service, New Castle County Department of Planning, Red Clay Creek Valley Association and private citizens in supplying useful data are appreciated.

* * *

The report presents the flood situation for Red Clay Creek from its confluence with White Clay Creek upstream to the Pennsylvania - Delaware State Line. The Philadelphia District of the Corps of Engineers will, upon request, provide interpretation and limited technical assistance in the application of data presented in this report.

* * *

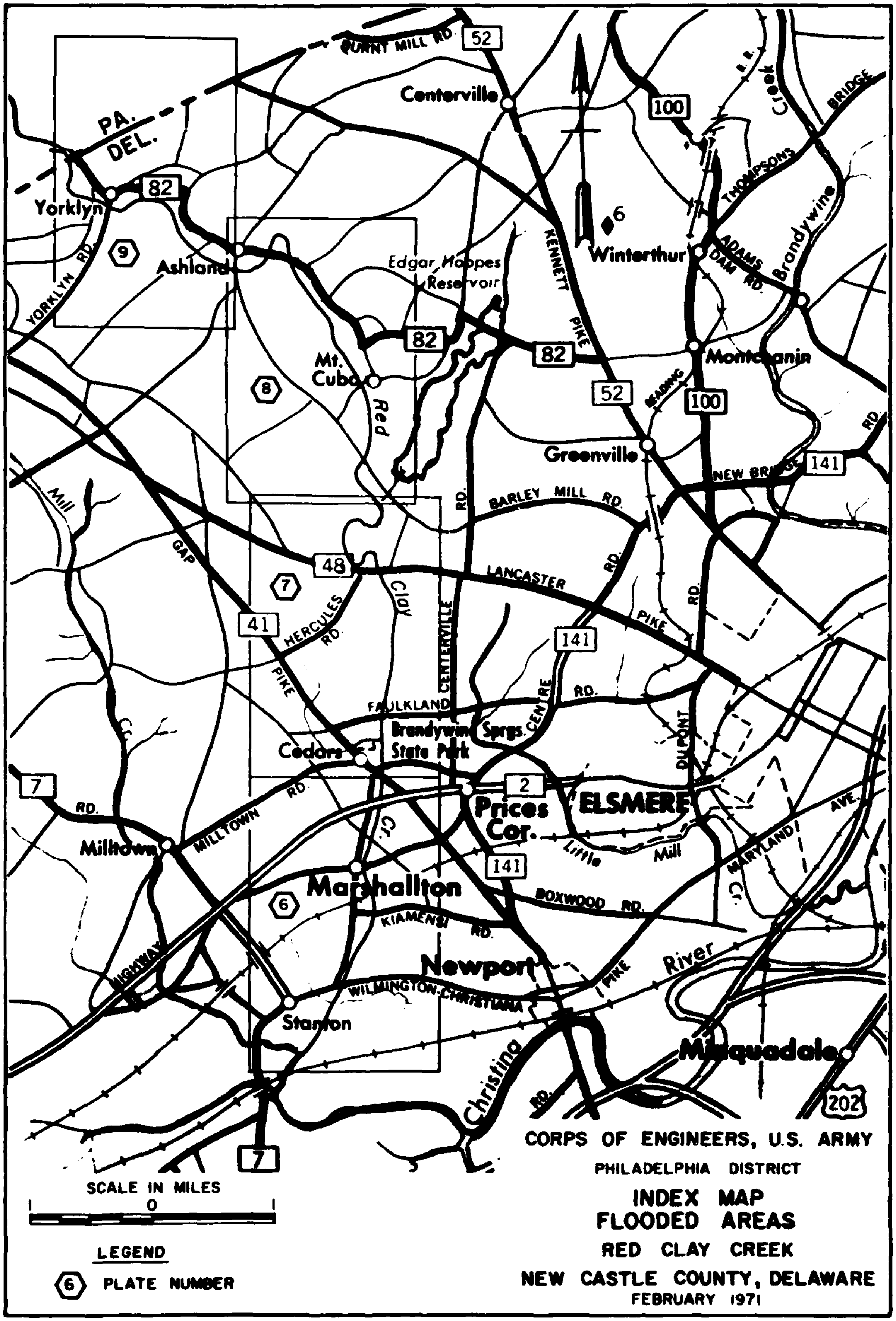
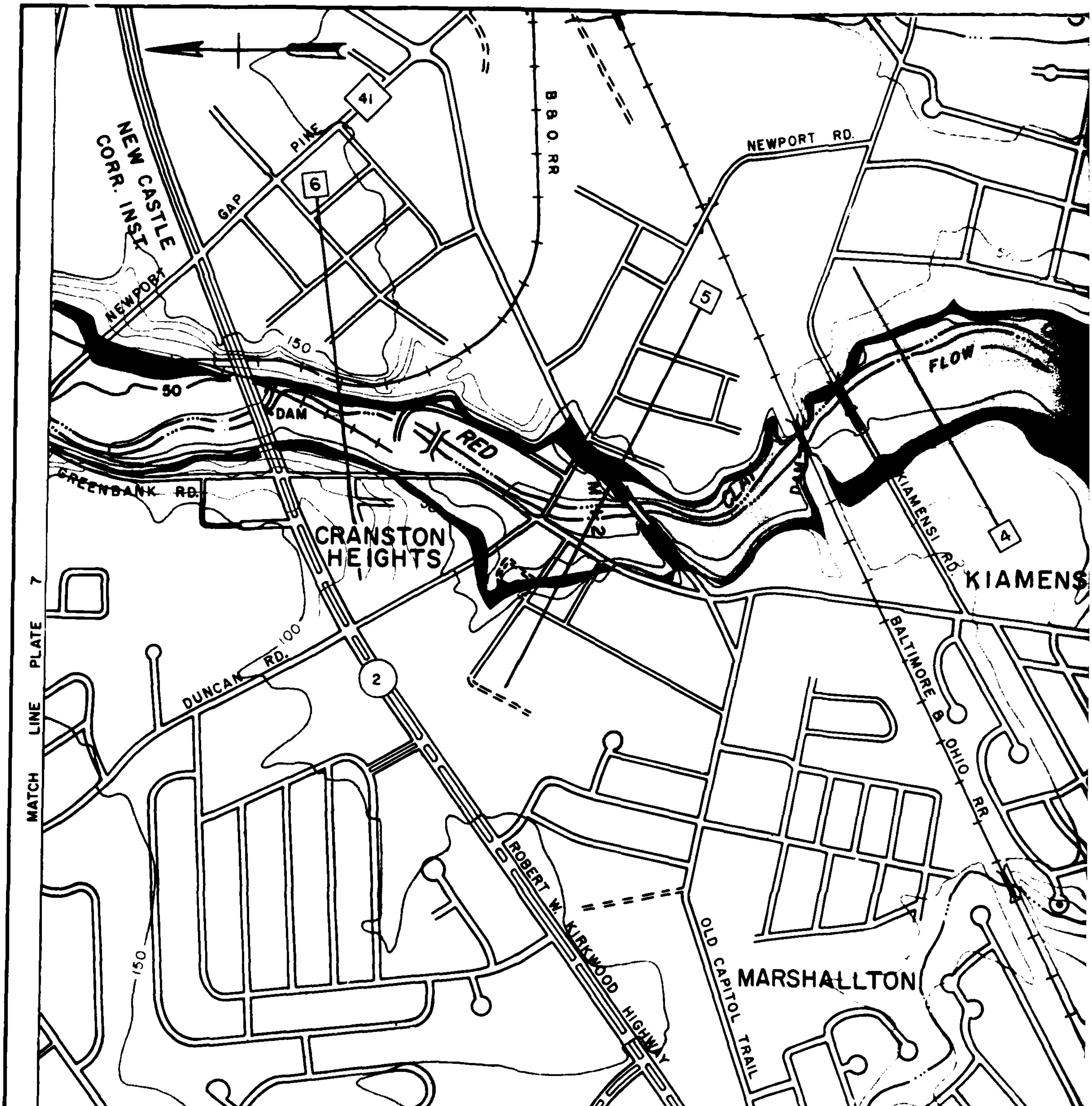
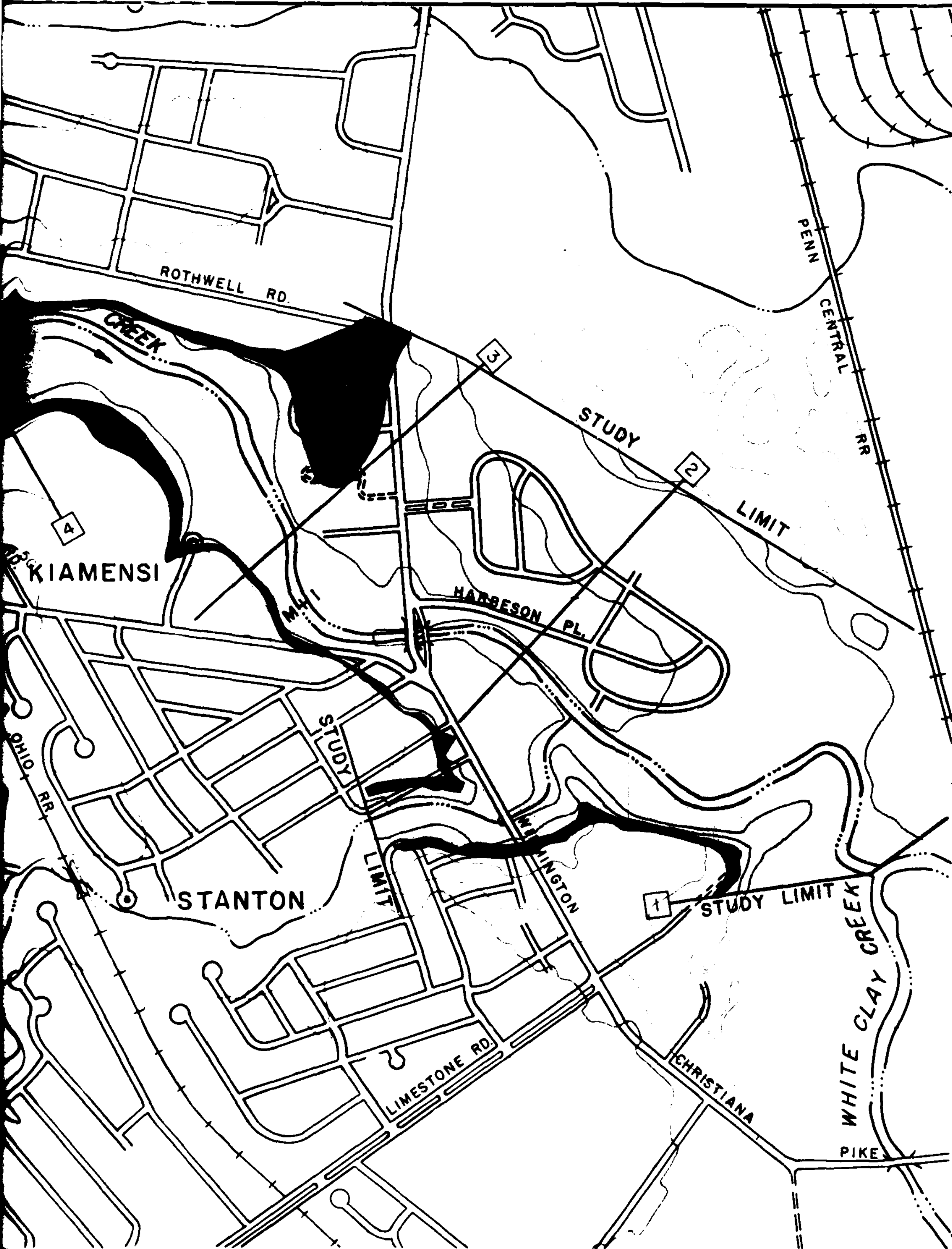

CORPS OF ENGINEERS, U.S. ARMY
PHILADELPHIA DISTRICT
INDEX MAP
FLOODED AREAS
RED CLAY CREEK
NEW CASTLE COUNTY, DELAWARE
FEBRUARY 1971
SCALE IN MILES
0
LEGEND
6 PLATE NUMBER
PA.
DEL.
Yorklyn
Ashland
Mt. Cuba
Centerville
Winterthur
Montchanin
Greenville
Edgar Hoopes Reservoir
Cedars
Brandywine Sprgs State Park
Prices Cor.
ELSMERE
Milltown
Marshallton
Newport
Stanton
Minquadale
Red
Clay
Cr.
Mill
Cr.
Little Mill Cr.
Brandywine
Christina
River
KENNETT PIKE
LANCASTER PIKE
GAP PIKE
HERCULES RD.
FAULKLAND RD.
CENTERVILLE RD.
CENTRE RD.
DUPONT RD.
BARLEY MILL RD.
YORKLYN RD.
MILLTOWN RD.
BOXWOOD RD.
KIAMENSI RD.
WILMINGTON-CHRISTIANA PIKE
MARYLAND AVE.
NEW BRIDGE RD.
THOMPSONS BRIDGE
ADAMS DAM RD.
BEARING
HIGHWAY
52
82
100
141
48
41
7
2
202
9
8
7
6

PLATE 5



NEW CASTLE
CORR. INST.
41
6
PINE
GAP
NEWPORT
B. & O. RR
NEWPORT RD.
5
150
50
DAM
RED
FLOW
GREENBANK RD.
CRANSTON
HEIGHTS
DAM
4
KIAMENSI RD.
KIAMENS
MATCH LINE PLATE 7
100
DUNCAN RD.
2
BALTIMORE & OHIO RR
ROBERT W. KIRKWOOD HIGHWAY
OLD CAPITOL TRAIL
MARSHALLTON
150



LI

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INTERME

M + 6 MILES

2 CROSS

GROUND
(U.S.C. 8
LEVEL

NOTES:

1. LIMITS OF C
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LOCATION C
EXPLAINED

2. MINIMUM CO
IS 10 FEET.

CORPS OF EN
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RED C
NEW CASTLE

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0

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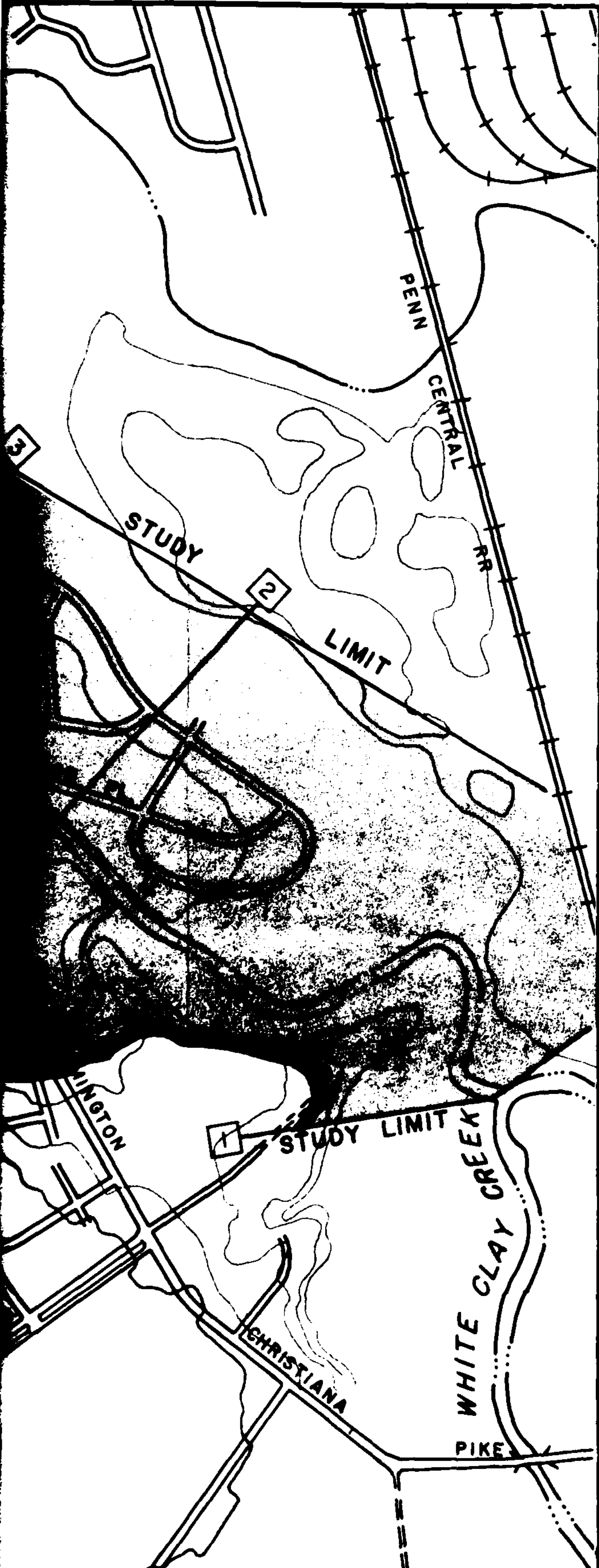


LEGEND

OVERFLOW LIMITS

STANDARD PROJECT FLOOD

INTERMEDIATE REGIONAL FLOOD

M + 6 MILES ABOVE MOUTH

2 CROSS SECTION

—150— GROUND ELEVATION IN FEET (U.S.C. & G.S. 1929 ADJ.) SEA LEVEL DATUM

NOTES:

1. LIMITS OF OVERFLOWS SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
2. MINIMUM CONTOUR INTERVAL IS 10 FEET.

CORPS OF ENGINEERS, U.S. ARMY
PHILADELPHIA DISTRICT

FLOODED AREAS

RED CLAY CREEK

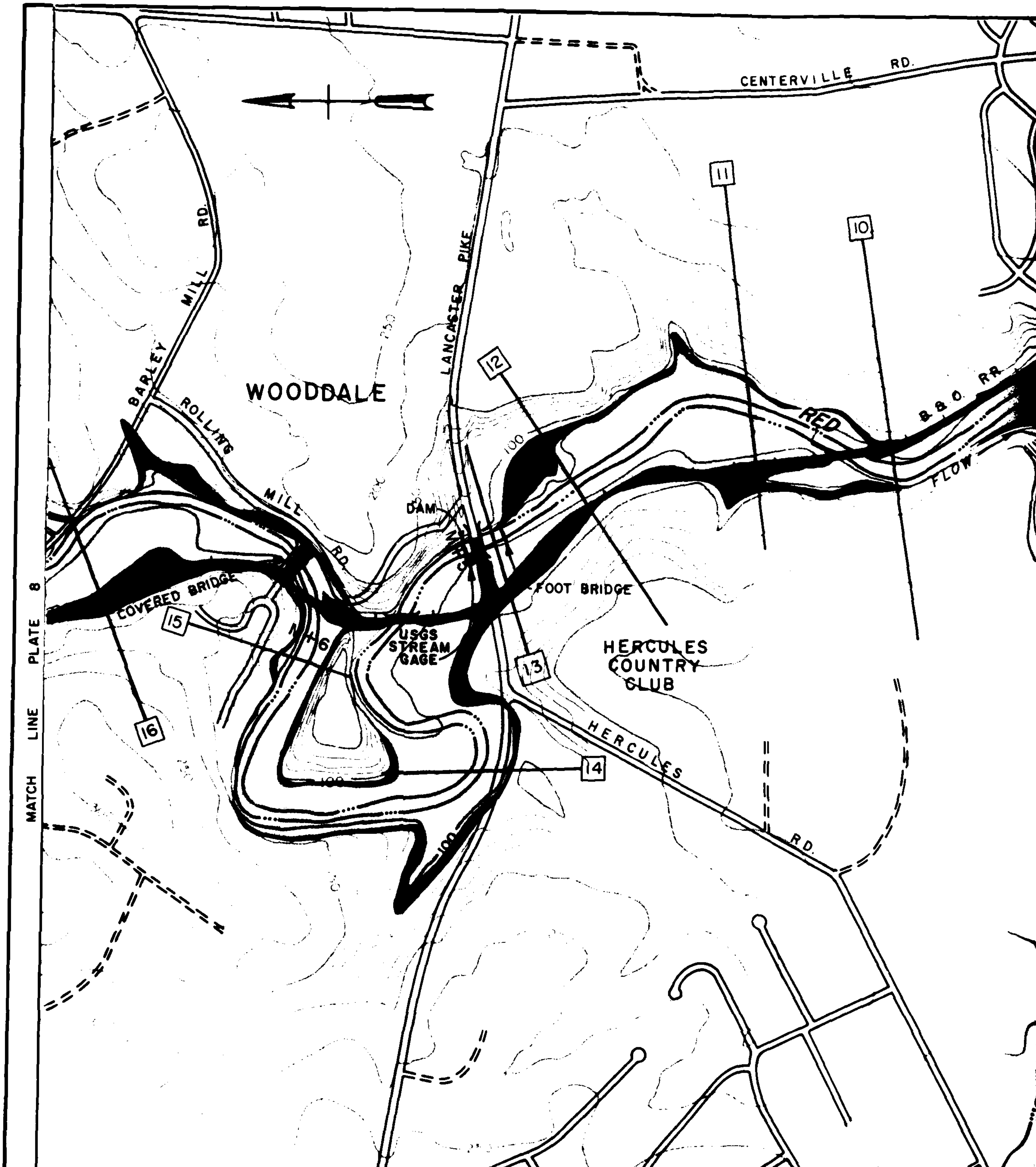
NEW CASTLE COUNTY, DELAWARE

SCALE IN FEET
0 800 1600

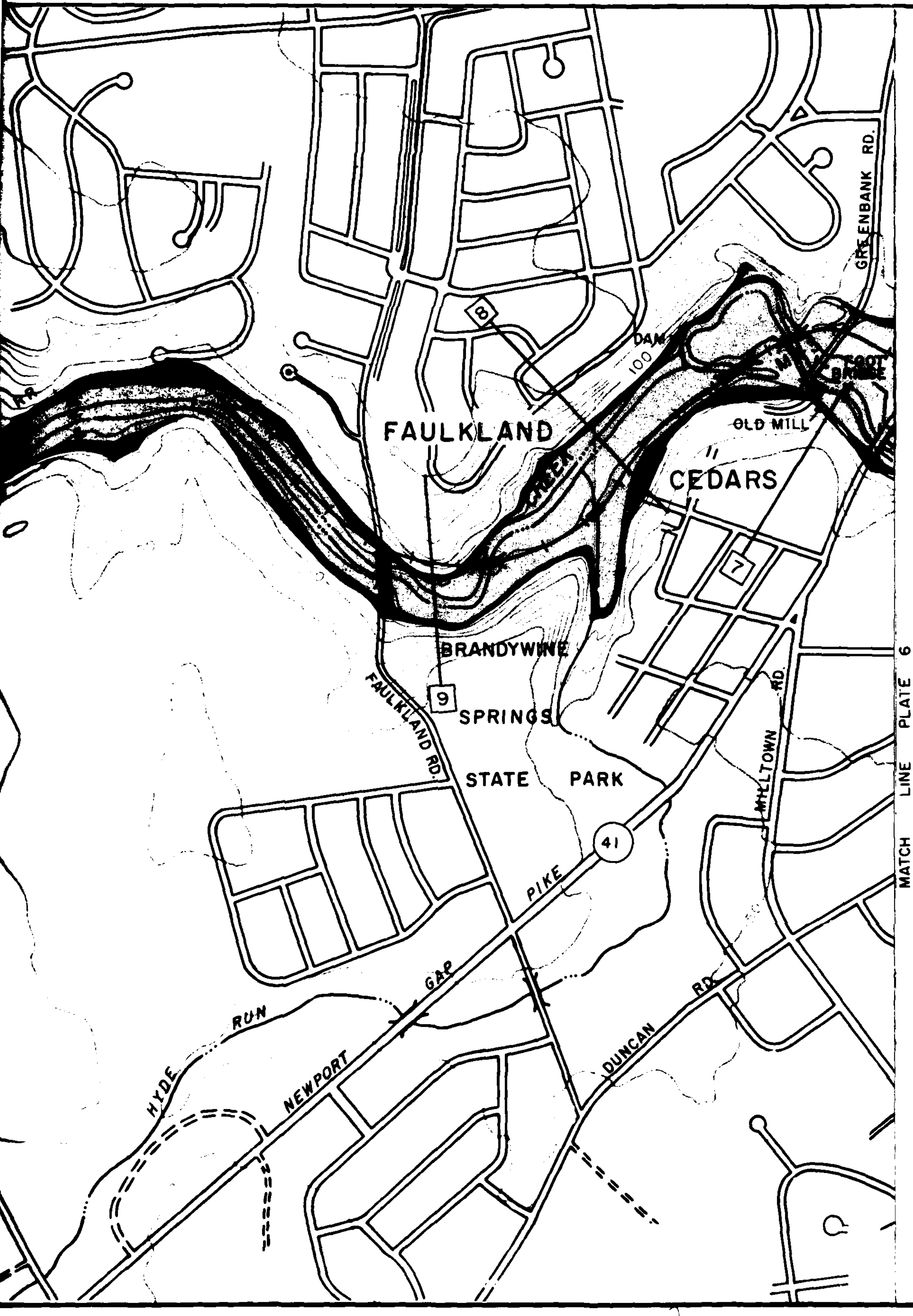
FEBRUARY 1971

2

PLATE 6 3



MATCH LINE PLATE 8
CENTERVILLE RD.
BARLEY MILL RD.
WOODDALE
LANCASTER PIKE
ROLLING MILL RD.
DAM
COVERED BRIDGE
FOOT BRIDGE
USGS STREAM GAGE
HERCULES COUNTRY CLUB
HERCULES RD.
RED
B & O RR
FLOW
100
11
10
12
13
14
15
16



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CORPS OF ENGINEE
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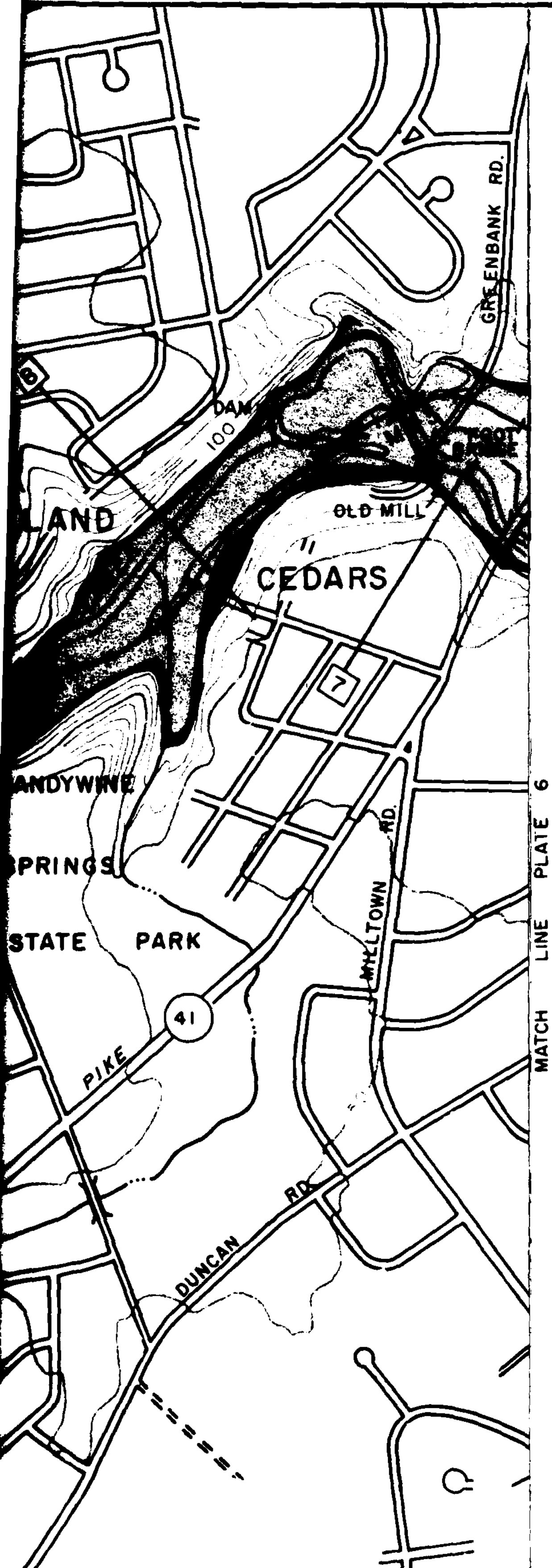

LEGEND

OVERFLOW LIMITS

STANDARD PROJECT FLOOD

INTERMEDIATE REGIONAL FLOOD

M + 6 MILES ABOVE MOUTH

2 CROSS SECTION

150 GROUND ELEVATION IN FEET (U.S.C. & G.S. 1929 ADJ.) SEA LEVEL DATUM

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CORPS OF ENGINEERS, U.S. ARMY

PHILADELPHIA DISTRICT

FLOODED AREAS

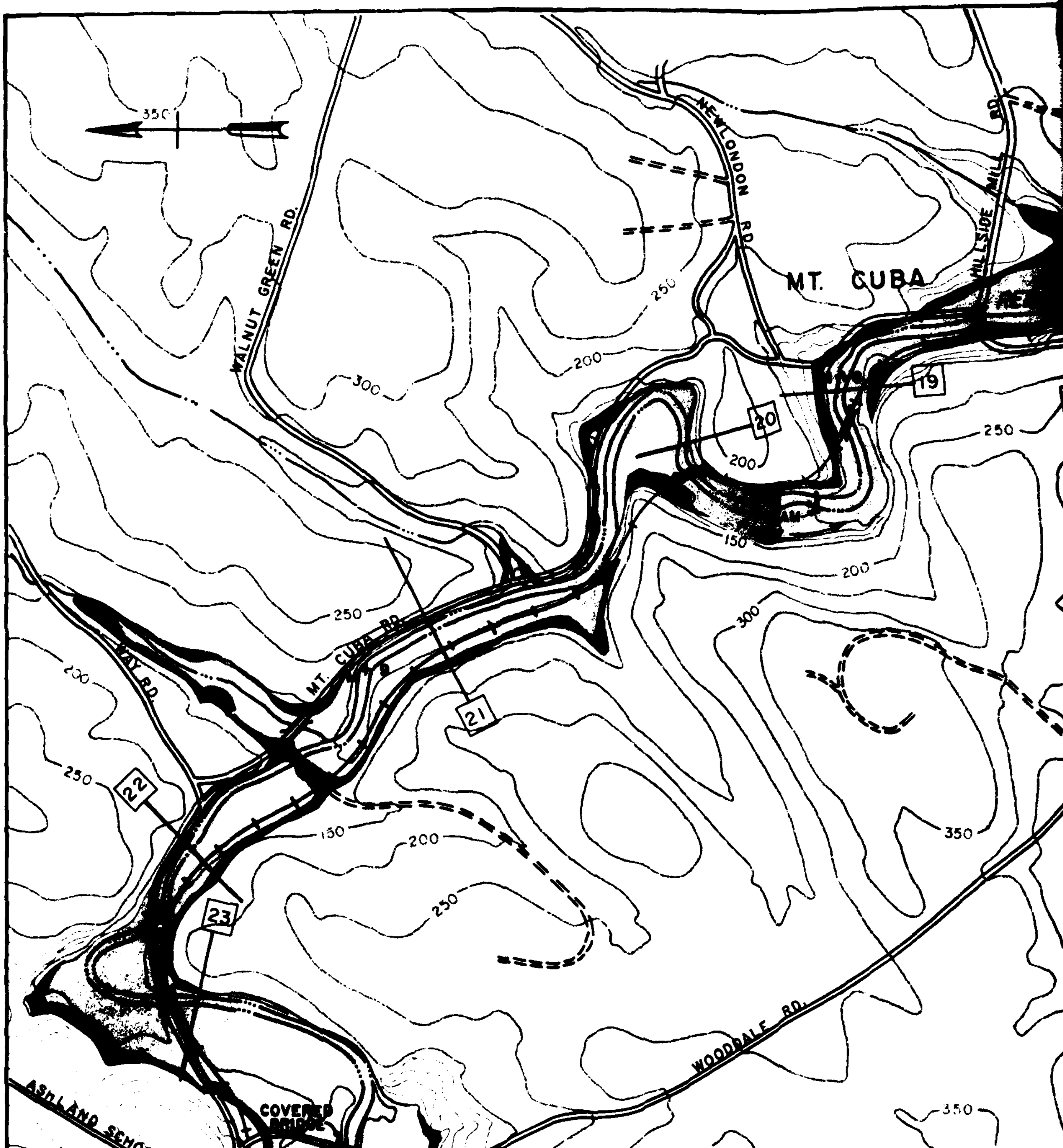
RED CLAY CREEK

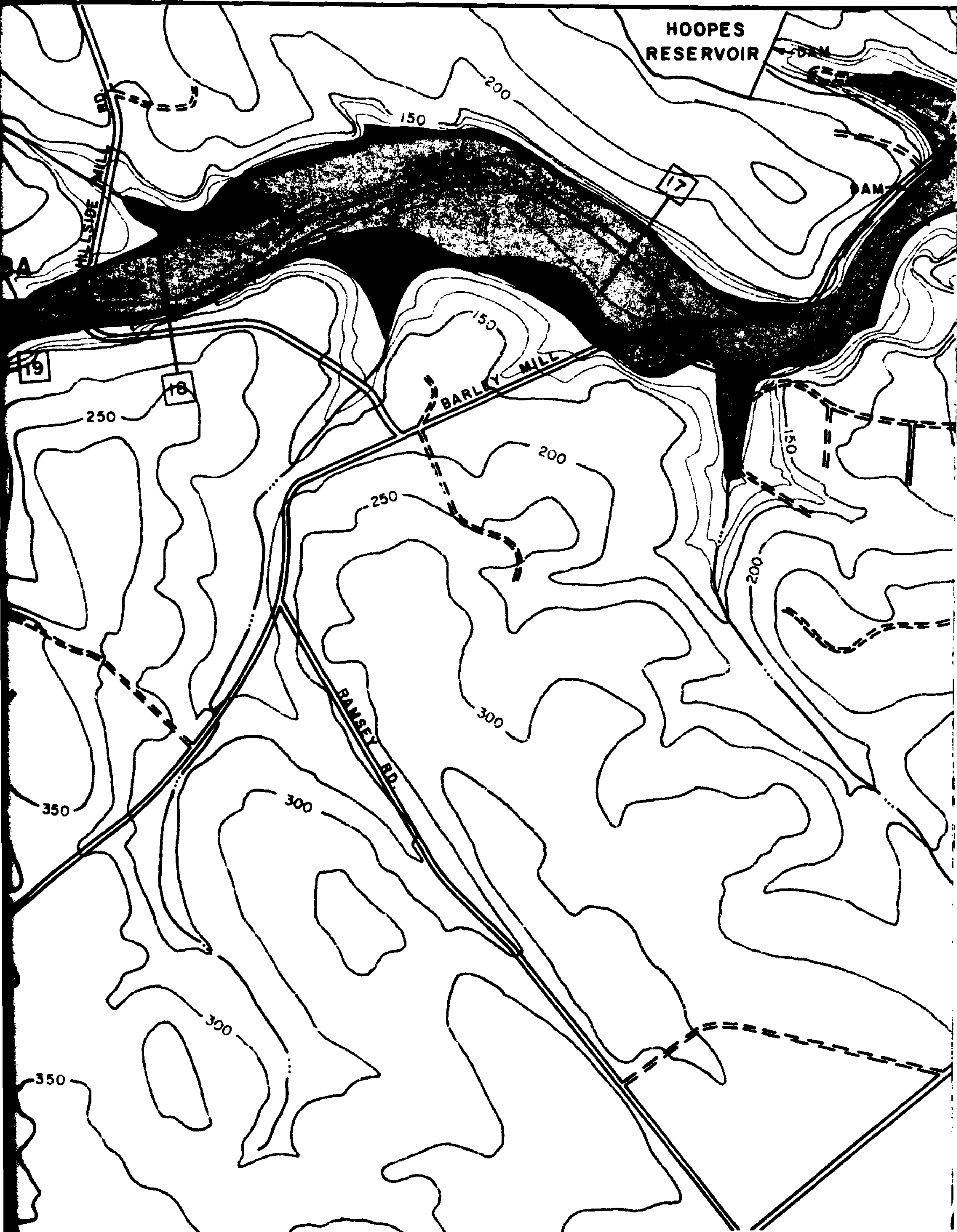
NEW CASTLE COUNTY, DELAWARE

SCALE IN FEET

0 800 1600

FEBRUARY 1971


NEW LONDON RD.
HILLSIDE MILL RD.
WALNUT GREEN RD.
MT. CUBA
MT. CUBA RD.
WAY RD.
WOODDALE RD.
ASHLAND SCHOOL RD.
COVERED BRIDGE
ASHLAND
19
20
21
22
23
350
300
250
200
150
MATCH LINE PLATE 9



M + 6 M

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NOTES:

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LEGEND

OVERFLOW LIMITS

STANDARD PROJECT FLOOD

INTERMEDIATE REGIONAL FLOOD

M + 6 MILES ABOVE MOUTH

2 CROSS SECTION

150 GROUND ELEVATION IN FEET (U.S.C. & G.S. 1929 ADJ.) SEA LEVEL DATUM

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CORPS OF ENGINEERS, U.S. ARMY
PHILADELPHIA DISTRICT

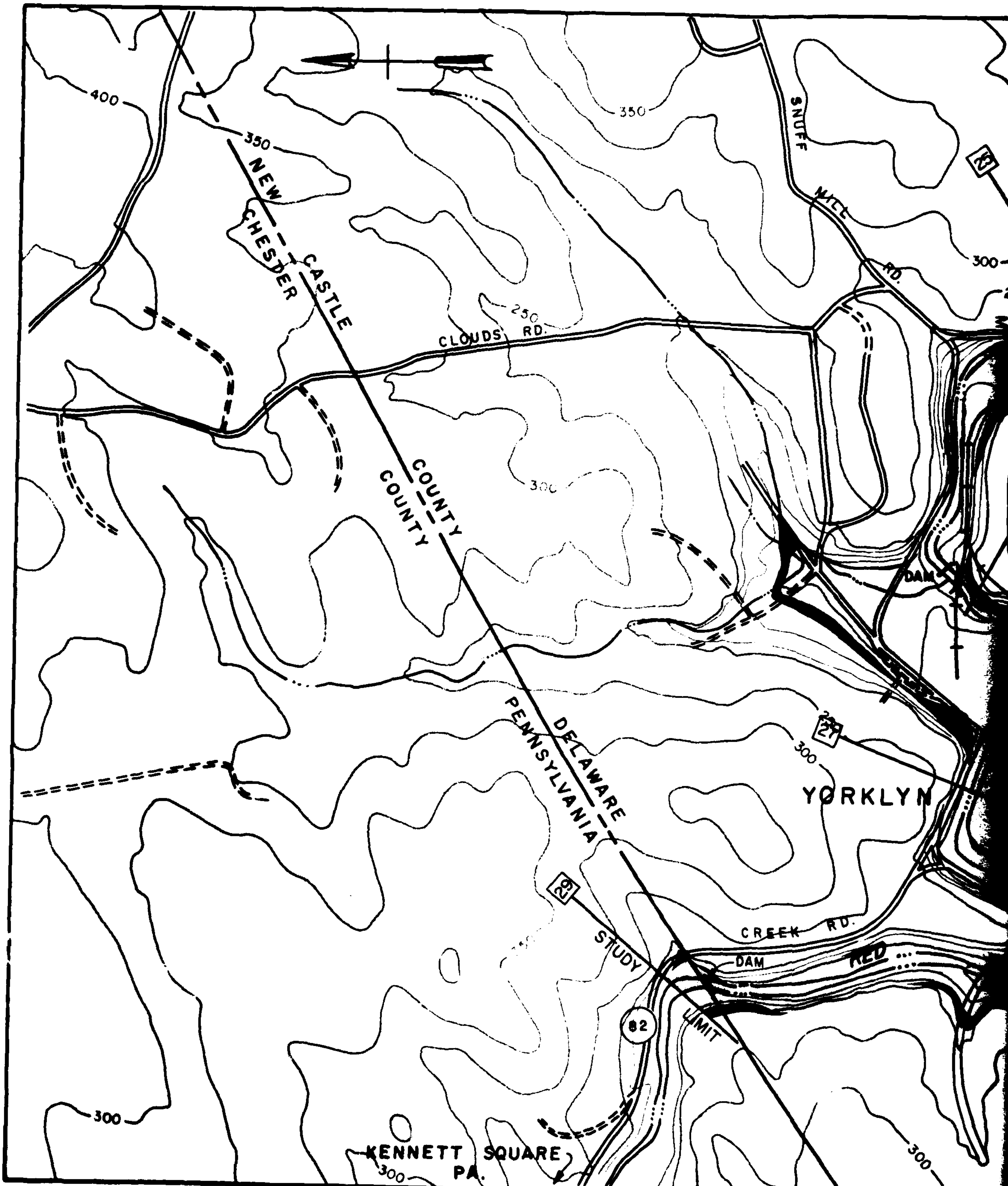
FLOODED AREAS

RED CLAY CREEK

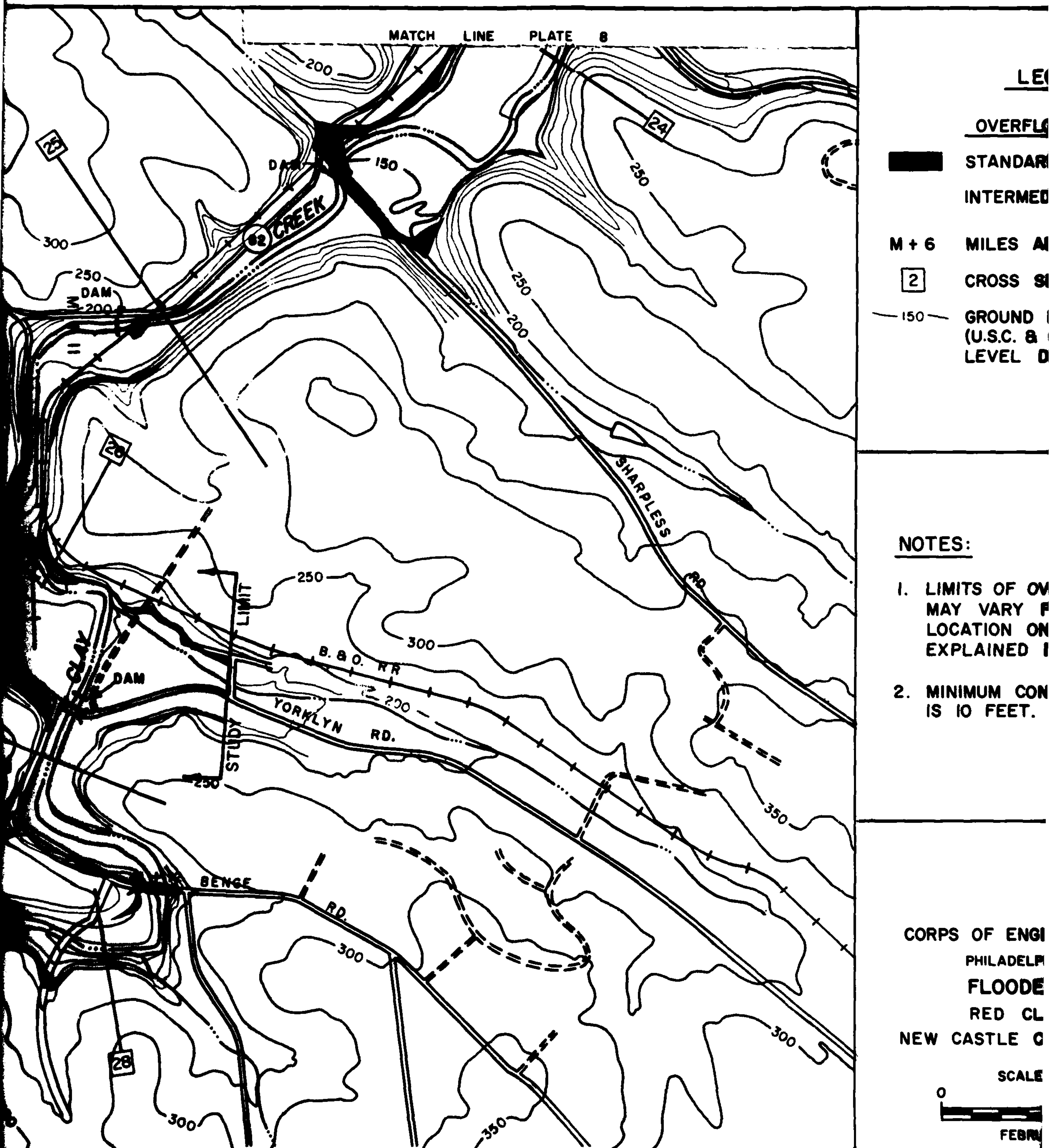
NEW CASTLE COUNTY, DELAWARE

SCALE IN FEET
0 800 1600

FEBRUARY 1971



400
350
NEW CASTLE COUNTY
CHESTER COUNTY
SNUFF MILL RD.
300
250
CLOUDS RD.
300
DAM
DELAWARE
PENNSYLVANIA
27
YORKLYN
29
STUDY LIMIT
CREEK RD.
DAM
RED
82
300
KENNETT SQUARE PA.
300
300


MATCH LINE PLATE 8
200
150
DAM
CREEK
82
300
250
DAM
200
25
24
250
250
200
26
SHARPLESS
RD.
250
300
STUDY LIMIT
B. & O. RR
CLAY
DAM
200
YORKLYN RD.
250
350
BENGE RD.
300
300
28
300
350
LE
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CROSS S
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GROUND
(U.S.C. &
LEVEL D
NOTES:
1. LIMITS OF OV
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2. MINIMUM CON
IS 10 FEET.
CORPS OF ENGI
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RED CL
NEW CASTLE C
SCALE
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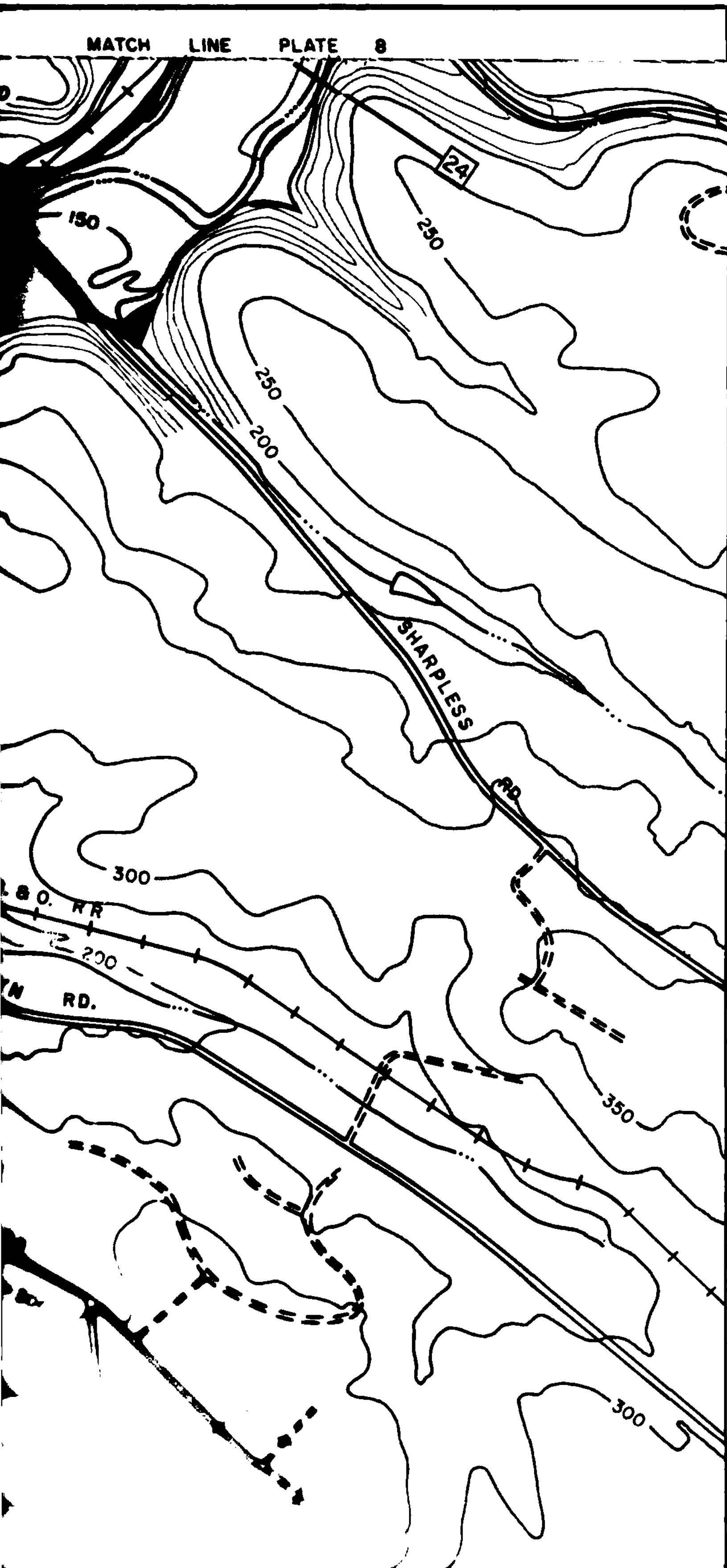

LEGEND

OVERFLOW LIMITS

STANDARD PROJECT FLOOD

INTERMEDIATE REGIONAL FLOOD

M + 6 MILES ABOVE MOUTH

2 CROSS SECTION

150 GROUND ELEVATION IN FEET (U.S.C. & G.S. 1929 ADJ.) SEA LEVEL DATUM

NOTES:

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CORPS OF ENGINEERS, U.S. ARMY

PHILADELPHIA DISTRICT

FLOODED AREAS

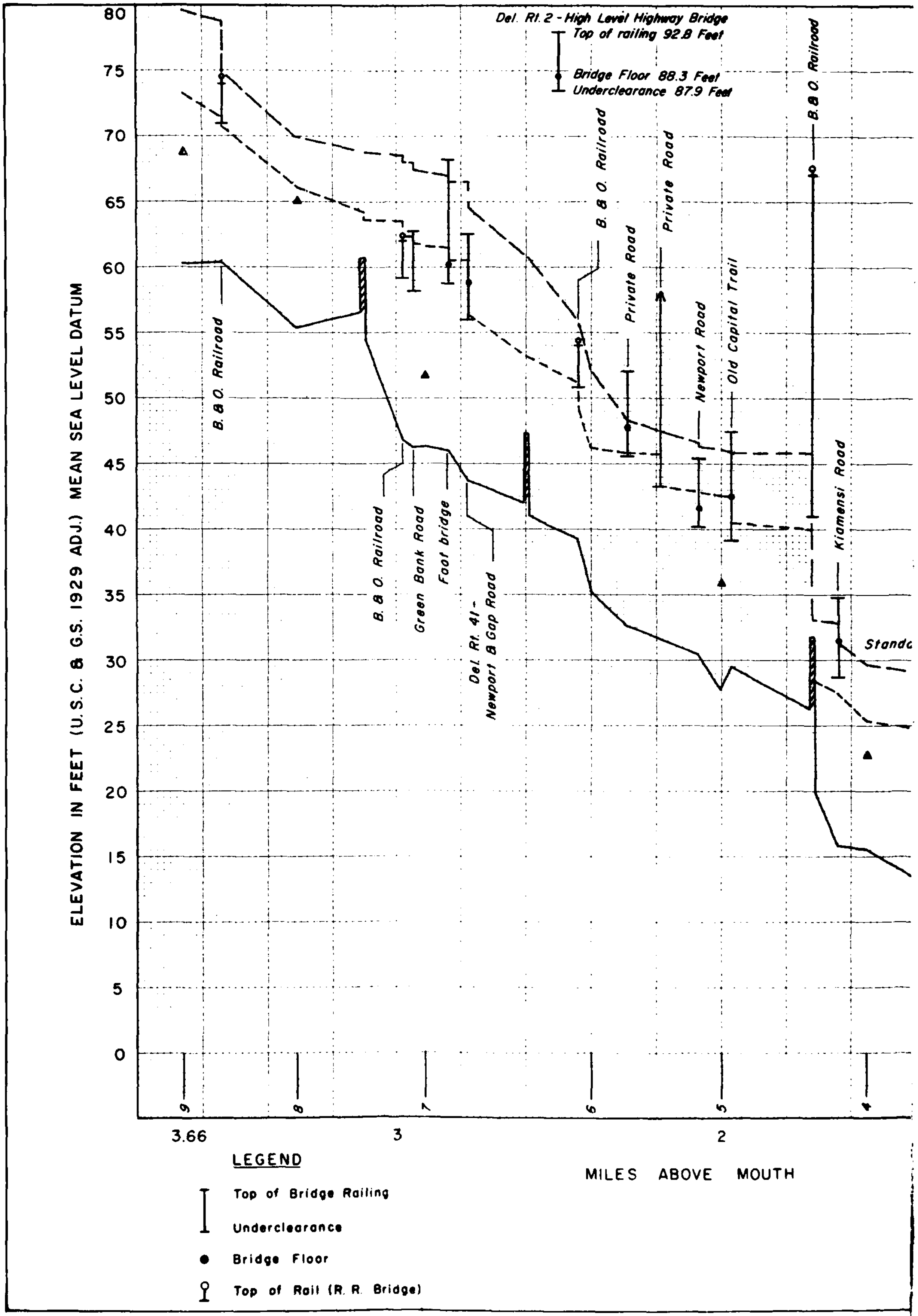
RED CLAY CREEK

NEW CASTLE COUNTY, DELAWARE

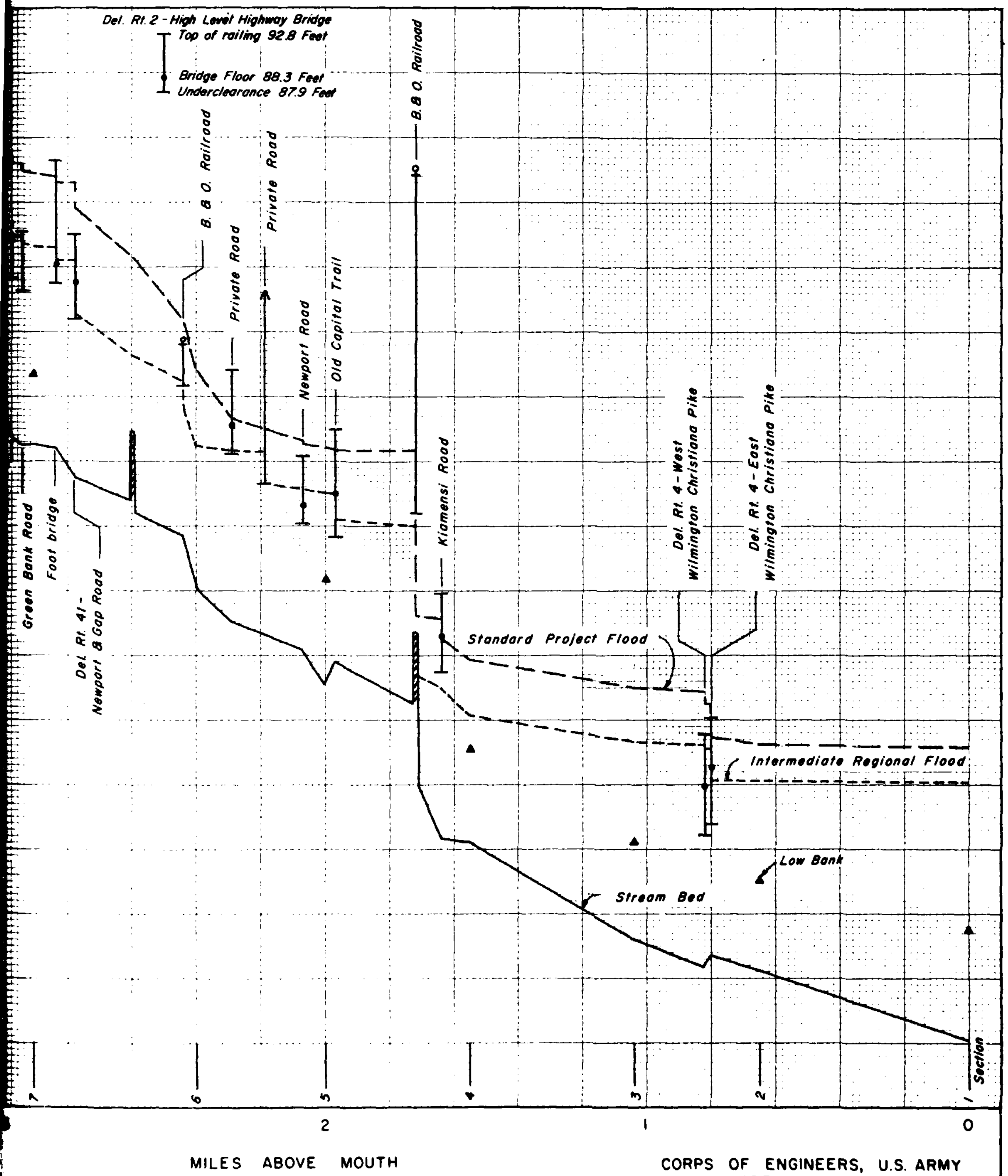
SCALE IN FEET

0 800 1600

FEBRUARY 1971



Del. Rt. 2 - High Level Highway Bridge
Top of railing 92.8 Feet
Bridge Floor 88.3 Feet
Underclearance 87.9 Feet
ELEVATION IN FEET (U.S.C. & G.S. 1929 ADJ.) MEAN SEA LEVEL DATUM
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
B. & O. Railroad
B. & O. Railroad
Green Bank Road
Foot bridge
Del. Rt. 41 - Newport & Gap Road
B. & O. Railroad
Private Road
Private Road
Newport Road
Old Capital Trail
B. & O. Railroad
Kiamensi Road
Standa
9
8
7
6
5
4
3.66
3
2
MILES ABOVE MOUTH
LEGEND
Top of Bridge Railing
Underclearance
Bridge Floor
Top of Rail (R. R. Bridge)

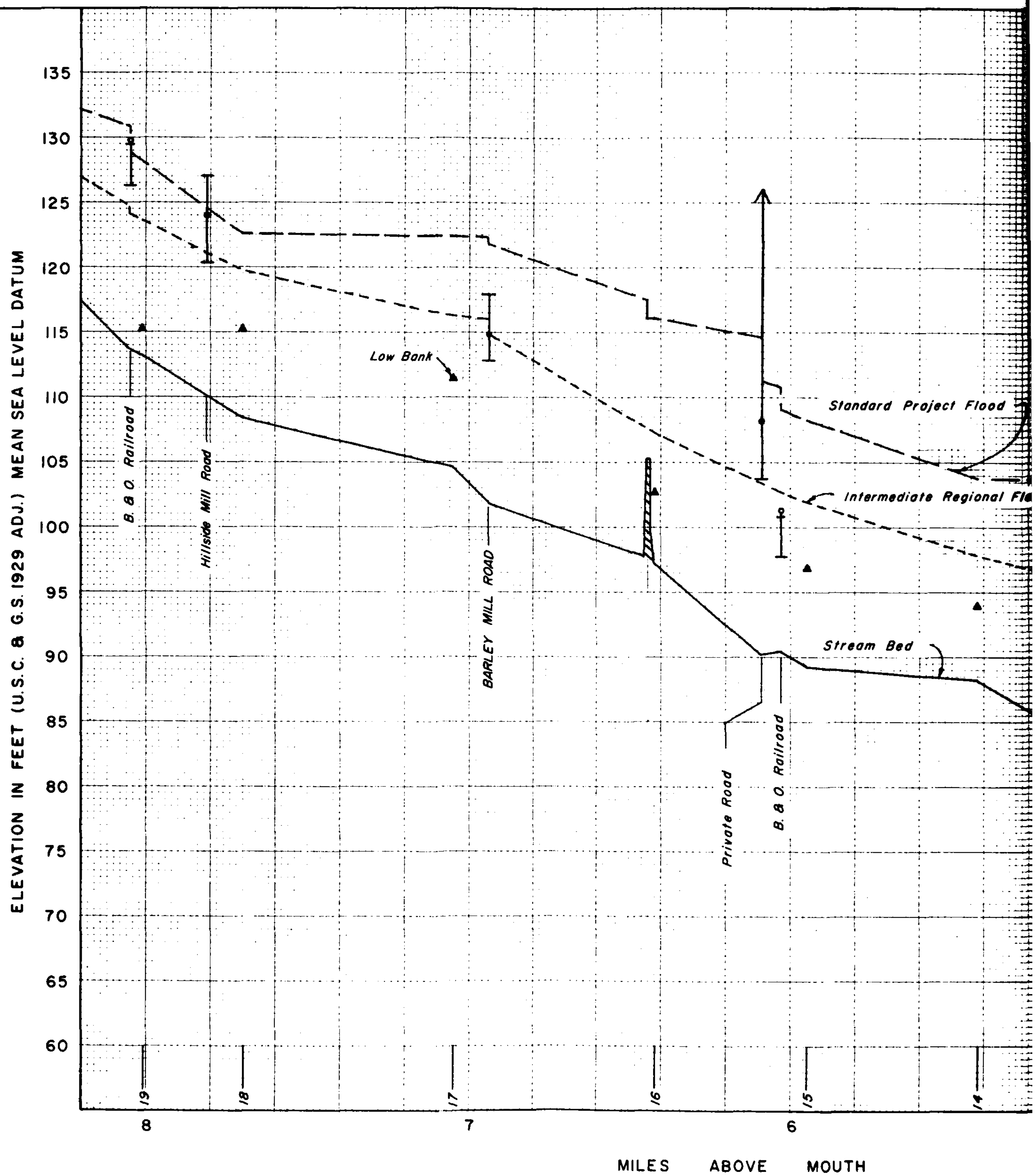


CORPS OF ENGINEERS, U.S. ARMY
PHILADELPHIA DISTRICT

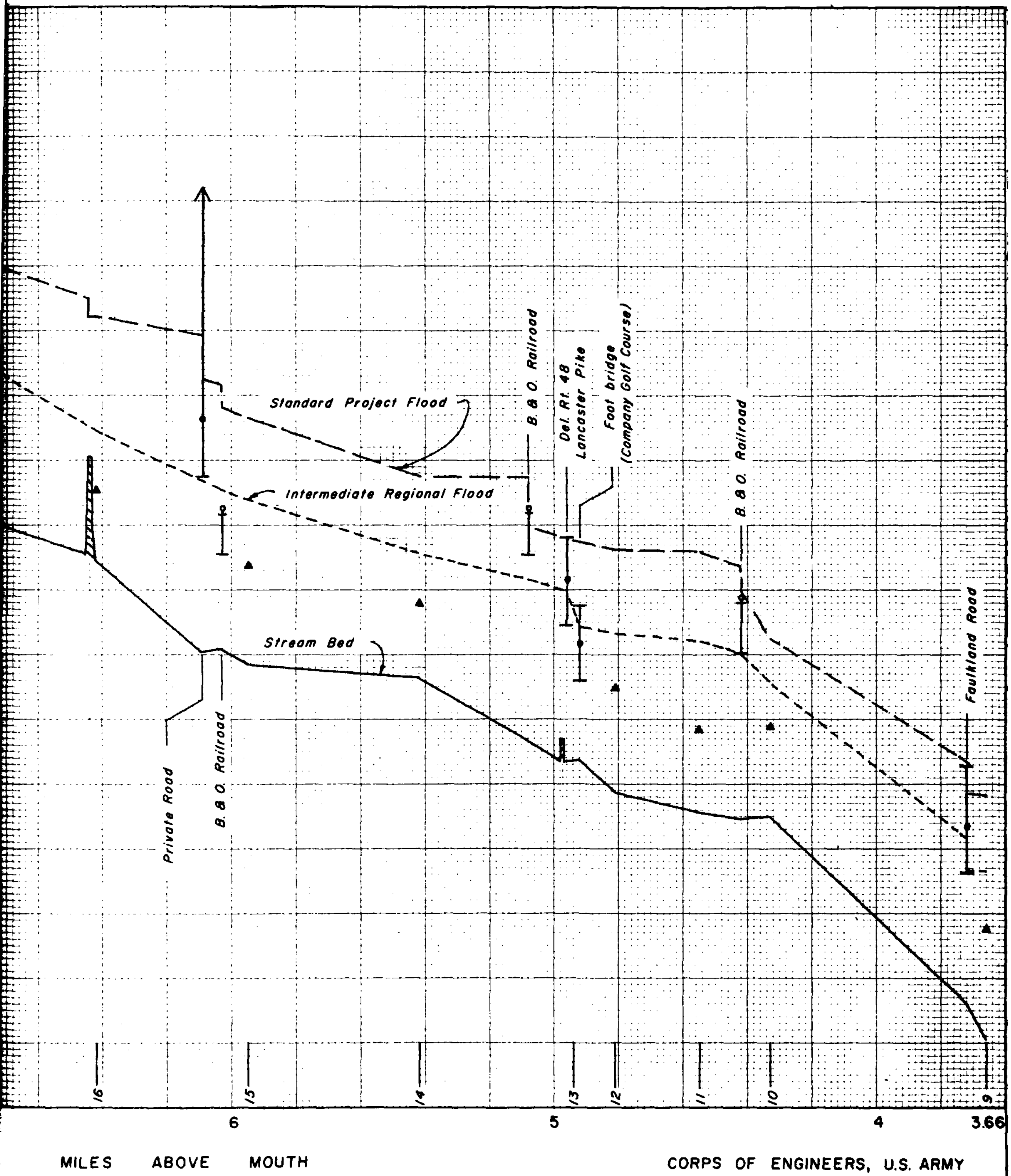
HIGH WATER PROFILE

RED CLAY CREEK
NEW CASTLE COUNTY
DELAWARE
FEBRUARY 1971

PLATE 10



FOR LEGEND SEE PLATE 10.

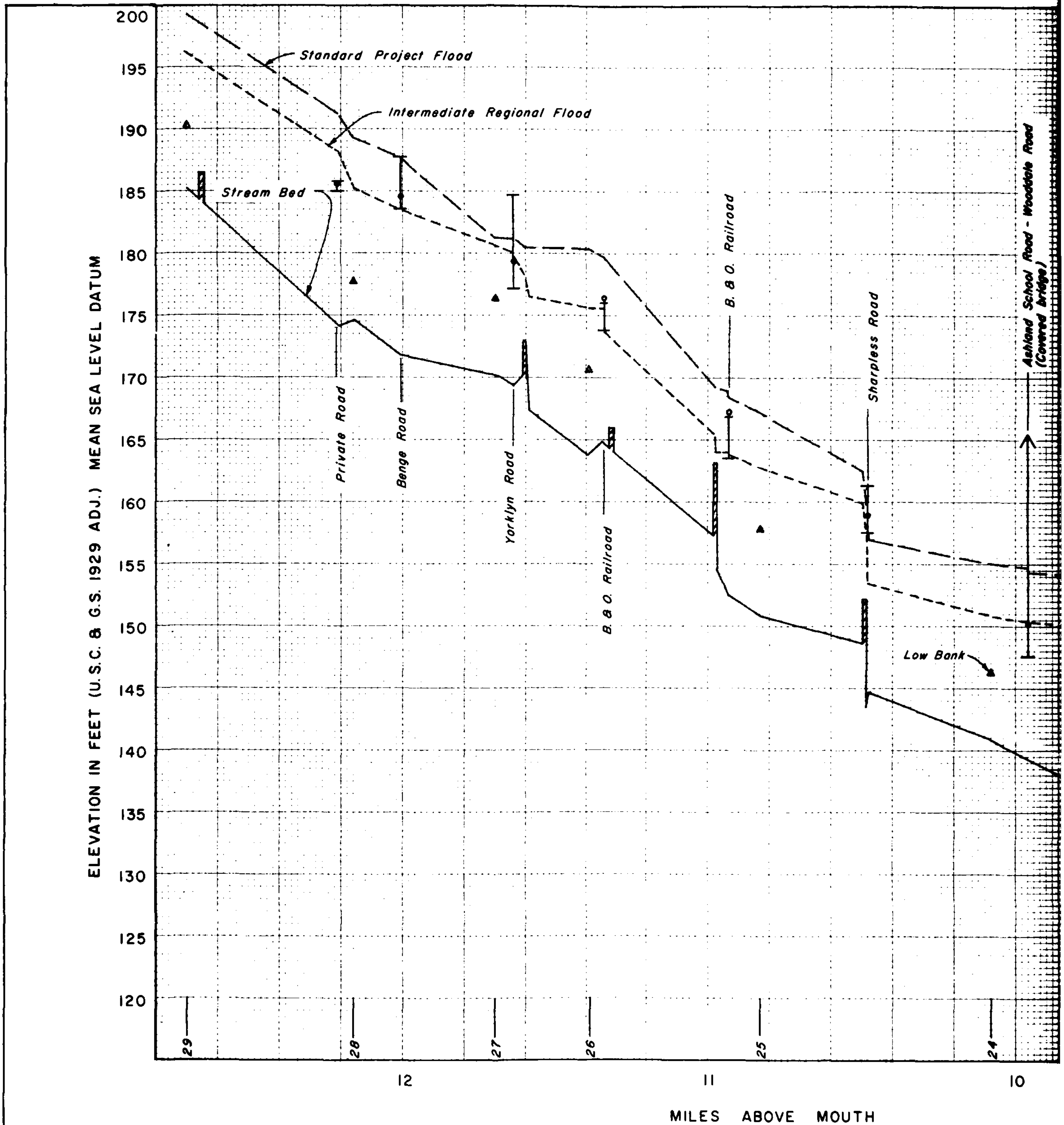


CORPS OF ENGINEERS, U.S. ARMY
PHILADELPHIA DISTRICT

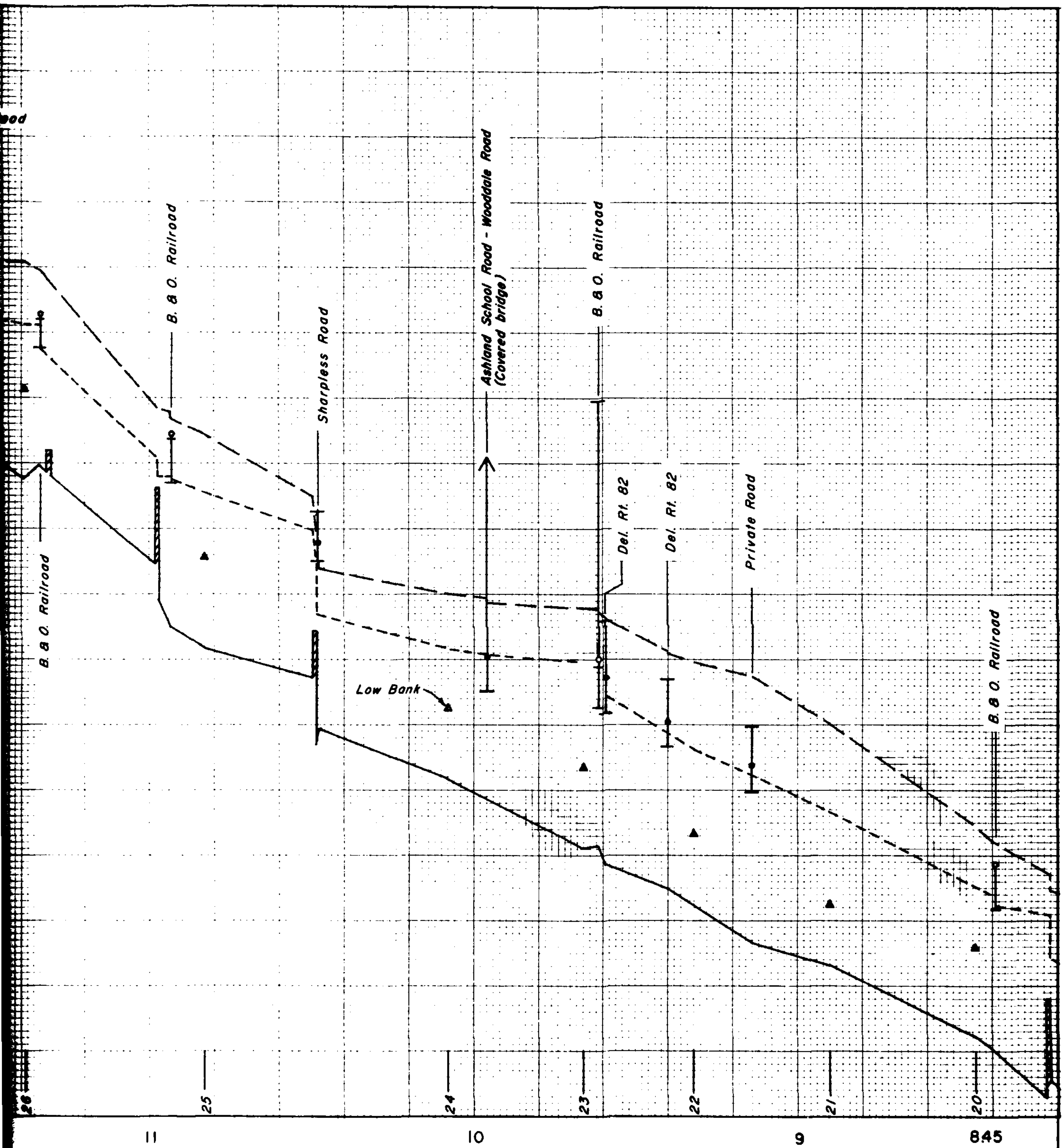
HIGH WATER PROFILE

RED CLAY CREEK
NEW CASTLE COUNTY
DELAWARE
FEBRUARY 1971

PLATE 11



FOR LEGEND SEE PLATE 10.



MILES ABOVE MOUTH

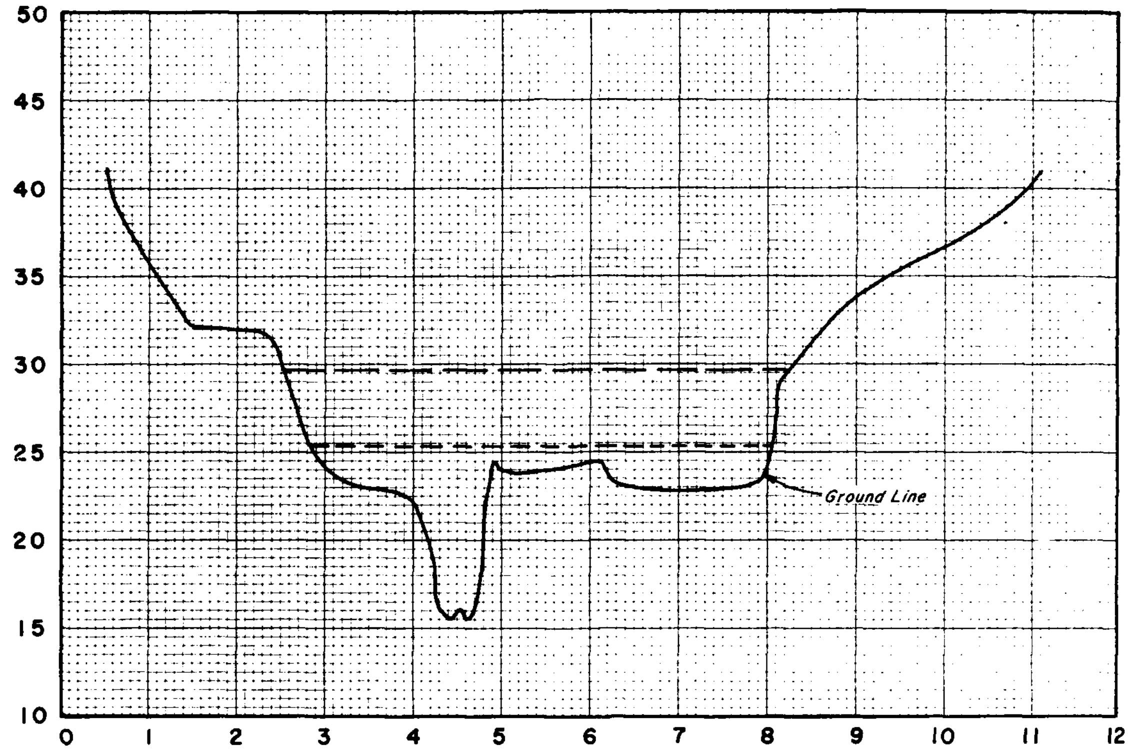
CORPS OF ENGINEERS, U.S. ARMY
PHILADELPHIA DISTRICT

HIGH WATER PROFILE

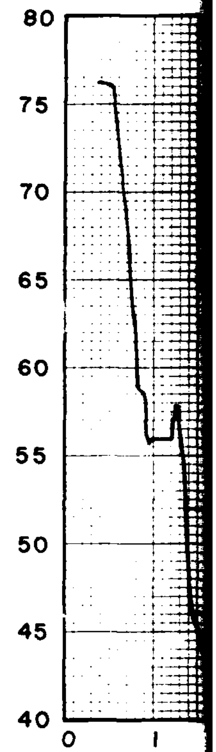
RED CLAY CREEK
NEW CASTLE COUNTY
DELAWARE
FEBRUARY 1971

PLATE 12

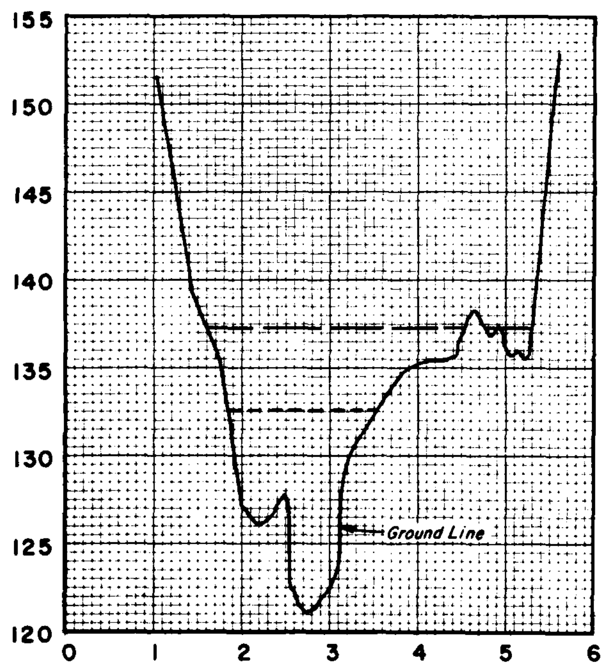
ELEVATION IN FEET (U.S.C. & G.S. 1929 ADJ.) SEA LEVEL DATUM



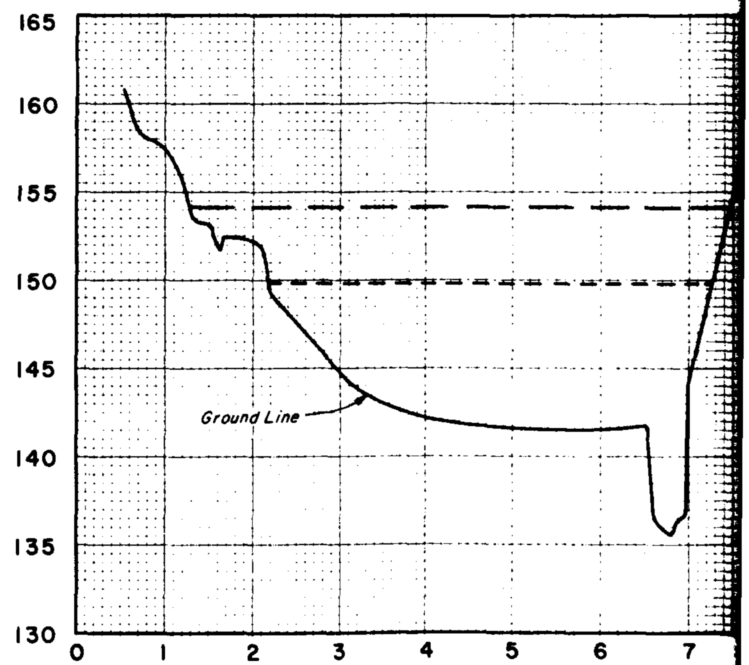
CROSS SECTION NO. 4
MILE 1.55



CRO

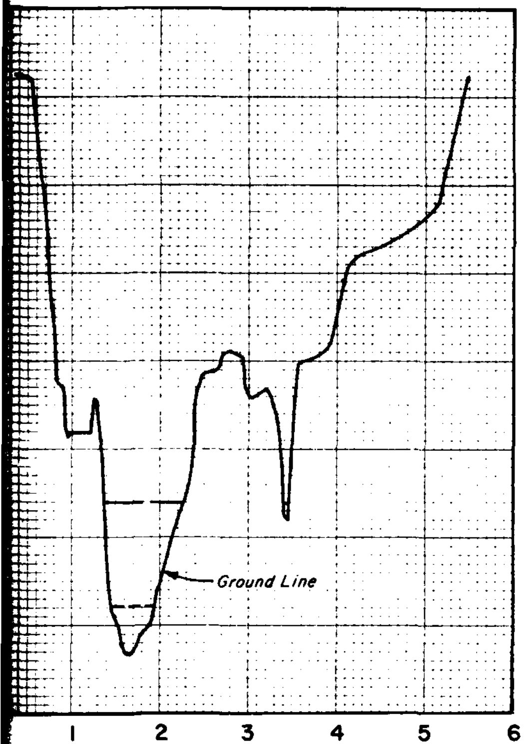


CROSS SECTION NO. 20
MILE 8.45

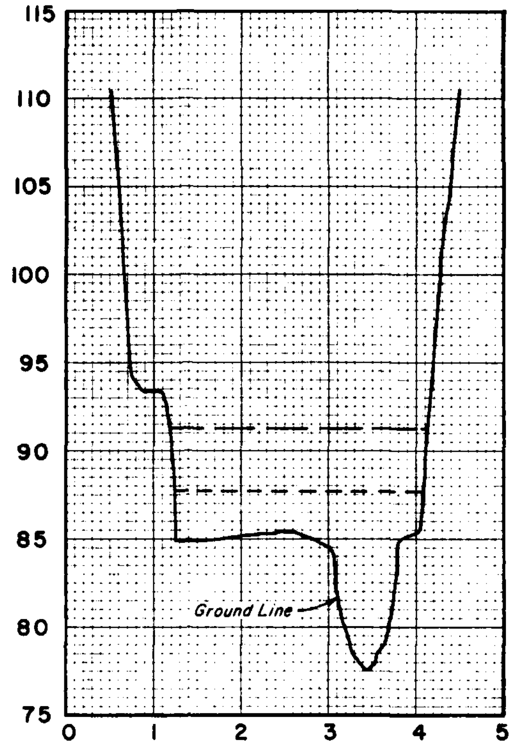


CROSS SECTION NO. 23
MILE 9.66

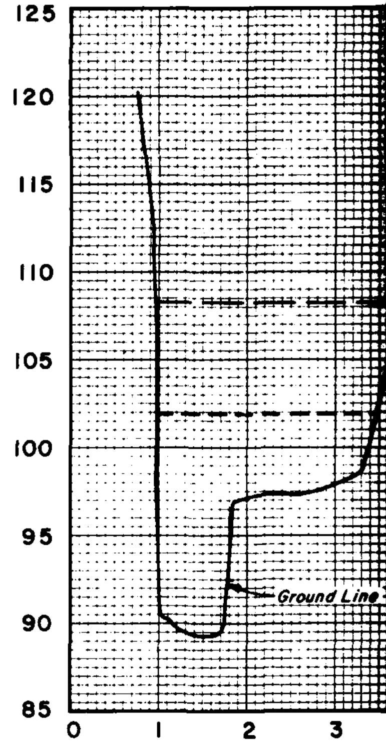
HORIZONTAL DISTANCE IN



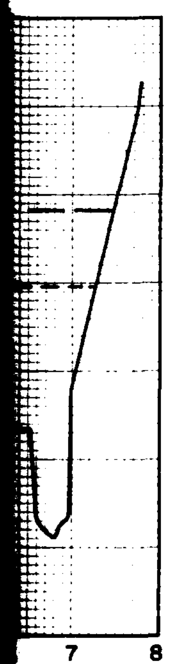
CROSS SECTION NO. 6
MILE 2.40

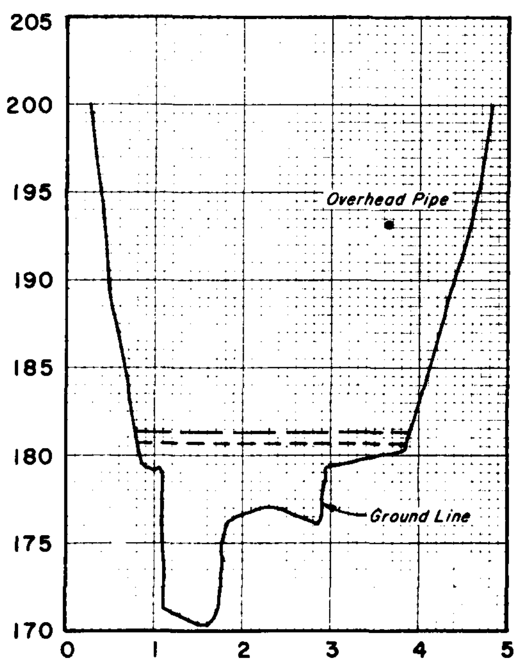


CROSS SECTION NO. 10
MILE 4.33

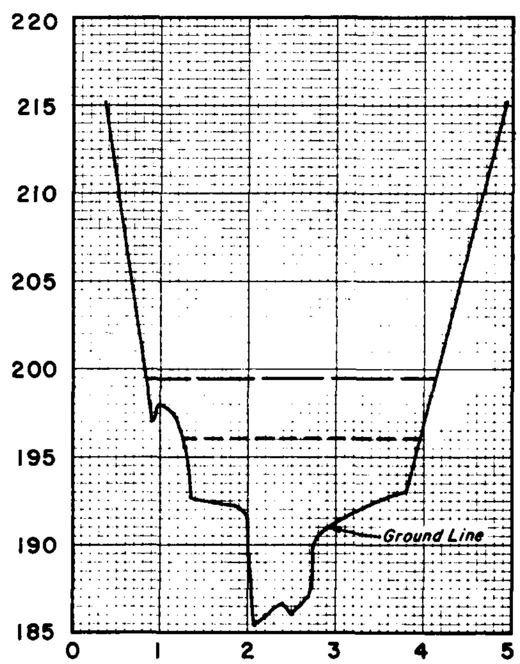


CROSS SECTION NO.
MILE 5.95





CROSS SECTION NO. 27
MILE 11.70



CROSS SECTION NO. 29
MILE 12.65

LEG

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21 Sections not sho

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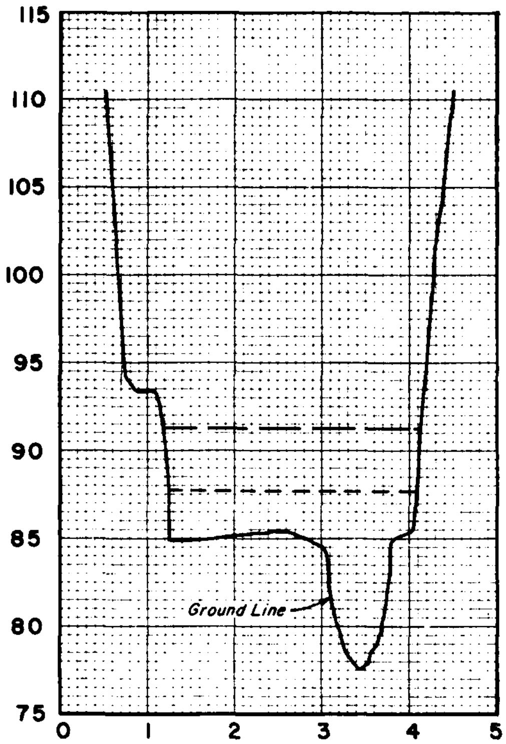
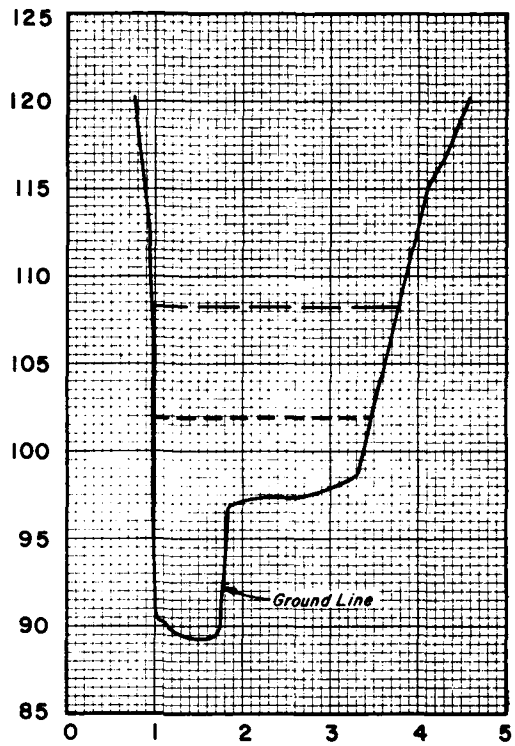
RED

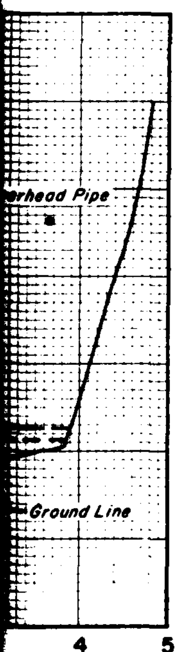
NEW



CROSS SECTION NO. 10
MILE 4.33



CROSS SECTION NO. 15
MILE 5.95



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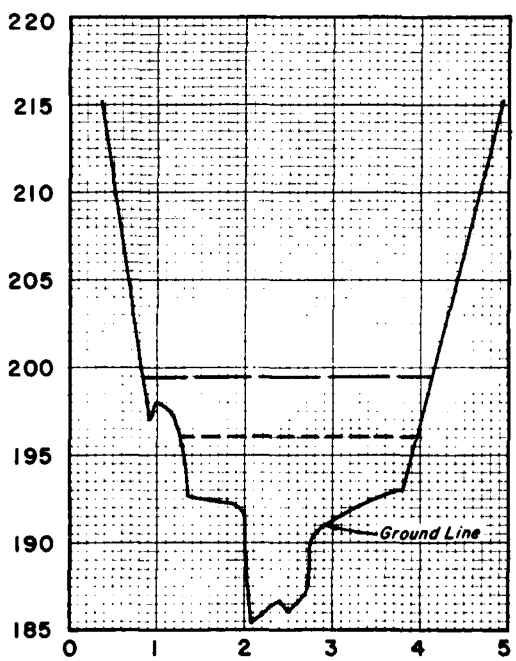

CROSS SECTION NO. 29
MILE 12.65

LEGEND

———— Standard Project Flood
– – – – – Intermediate Regional Control
Sections Taken looking downstream
21 Sections not shown

CORPS OF ENGINEERS, U.S. ARMY
PHILADELPHIA DISTRICT

CROSS SECTIONS

RED CLAY CREEK
NEW CASTLE COUNTY
DELAWARE
FEBRUARY 1971

PLATE 13